THE MILK QUESTION

BY M. J. ROSENAU

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The Subjects Treated

Milk as a Food
Dirty Milk
Diseases caused by Infected Milk
Clean Milk
Pasteurization
Infant Mortality
From Farm to Consumer

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THE MILK QUESTION

BY

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TO

NATHAN STRAUS

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THE MILK QUESTION

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CHAPTER I

GENERAL CONSIDERATIONS

Looked at from one angle the milk question is only one small part of the pure-food problem. The pure-food problem, in turn, is only one chapter of the great book of hygiene and sanitation. From this view-point the milk question seems a limited, even a contracted subject, but a deeper insight into it discloses the fact that it has depth and breadth. It pervades the whole domain of preventive medicine and touches many economic and social forces. Clean milk is a vital problem touching humanity in every phase of its social fabric. It is a live and burning topic of the day. Finally, it illustrates, better than any single subject, many of the fundamental factors in preventive medicine.

During the course of these lectures I shall have many pleasant things to say about milk. I hope to be able to show that the making of clean milk is an ideal worthy of the best endeavors of any man. I shall also have many unpleasant things to relate about milk. It may seem at times that undue emphasis is placed upon disagreeable and distasteful facts, but it should be remembered that if it were not for these facts there would be no milk question.

Why we have a milk question

In the beginning we must ask ourselves this pertinent query: Why do we have a milk question? Why all this fuss about milk and milk products? We do not have a bread question, a grain question, a fruit question, or a vegetable question — these substances also represent standard

articles of diet. The answer is simple. We have a milk question because *milk is apt to be dangerous to health.* In fact, the milk question as we understand it to-day began only when it was shown that impure milk is apt to convey disease. This alone would be sufficient reason, but in addition we have several other important facts. One is that we cannot do without milk. It is true that several large nations comprising millions of people get along reasonably well without the use of the milk of the cow or of any of our mammalian friends — rather our domesticated slaves. Western civilization, however, has come to depend upon cow's milk as an essential article of diet for children and it has become a very important article of diet for adults; it is therefore no overstatement for us to say that milk is a necessary article of diet.

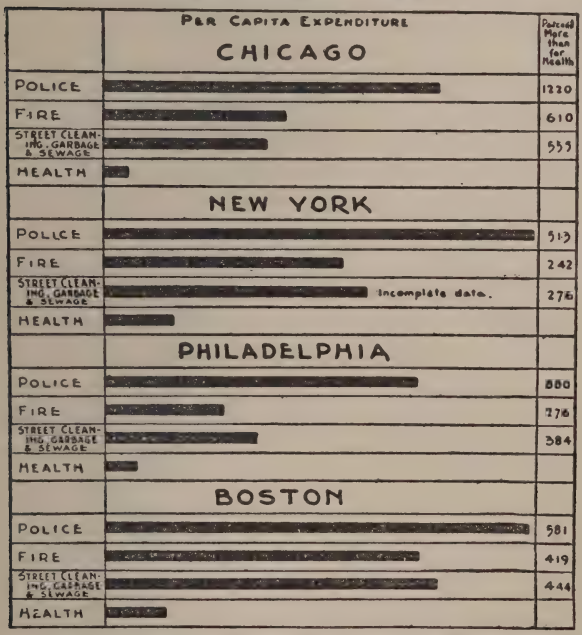
The next important reason why we have a milk question is that milk is the most difficult of all our standard articles of diet to obtain and handle in a safe and satisfactory manner. It requires scrupulous care from pasture to pail, and from pail to palate. It is the most difficult of all our foods to gather, handle, transport, and deliver in a fresh, clean, safe, and satisfactory manner. Furthermore, milk decomposes more quickly than any other food. It spoils even more quickly than fresh fruit and berries.

A further reason why we have a milk problem is because most milk is consumed raw. In fact, milk is the only important nitrogenous animal food commonly used without cooking. Possibly ninety per cent of all our food is first cooked. We have recently come to realize that uncooked articles such as water, milk, oysters, lettuce, etc., may convey infection. Cooking destroys germs. The disinfecting action to which food is subjected during cooking is one of the principal advantages of that process. Therefore, the sanitarian regards cooking as the most important hygienic safeguard that has ever been introduced by man for his protection.

There are many other reasons why we have a milk question. These will be discussed anon. We shall find that all this fuss about milk is not a "tempest in a tea-pot." We are

COMPARISON OF EXPENDITURES FOR IMPORTANT MUNICIPAL ACTIVITIES IN FOUR LEADING AMERICAN CITIES

(Tabulated for the year 1908 from U. S. Census Bureau, by the Chicago Commission of Health)



A SORRY CONTRAST. UNTIL COMMUNITIES ARE WILLING TO SPEND MORE FOR HEALTH WE WILL HAVE A MILK QUESTION AND OTHER SANITARY PROBLEMS

dealing with an essential article of food: one that is probably accountable for more sickness and more deaths than all other foods put together. The milk question is then a real problem of first magnitude worthy of our careful thought and attention.

Complexity of the milk problem

There is probably no single problem in the whole realm of modern sanitation and hygiene that is so complex, so involved, so intricate, and so harassing. The difficulties sometimes appear impossible to overcome; the dangers too subtle to guard against. There are those, whose judgment is worthy of consideration, who, after giving the milk question serious study, have come to the conclusion that it is unsolvable. The reasons for this are manifold. The milk problem rubs elbows with almost every phase of human activity. It has its health side, economic side, legal side, scientific side, sociologic side, legislative side, administrative side: it is a many-sided figure. The milk problem starts with the cradle and ends with the grave. Sometimes it leads to an untimely grave.

The milk question is solvable, and may be satisfactorily adjusted to meet all concerned. It shall be my privilege to present, later on, what I regard as the solution of this perplexing problem.

As an illustration to show how deep-rooted and how important the milk question has become, I need only call attention to the fact that it has invaded politics. In a number of cities and states the milk situation has become one of the leading political issues. To my thinking this is a favorable sign of the times, for, when health and social issues supplement the issues raised by war, or the personal and partisan issues which disgrace some of our campaigns, it shows that the refining influences of civilization are controlling the brute forces of passion. Instead of devising bigger and bigger guns to destroy, instead of training men to kill, the forces of society are now turning to the more ennobling uses of peace and the conservation of the greatest asset of a nation — health.

The introduction of the milk question into politics is not an unmixed evil. The sanitarian has long fought against

"I DRINK TO THE GENERAL DEATH OF THE WHOLE TABLE"

This cartoon was awarded the first prize by the American Medical Association. Such pictures probably do more harm than good, for they give an exaggerated notion of the danger in milk. This one gives the impression that every portion of milk is a potion of poison. Such overstatements are unfortunate, for common experience teaches that this cannot be true. There is a germ of truth in the picture, as there are supposed to be harmful germs in the bowl of milk.

the mischievous influence of machine politics in the administration of health matters. Health boards have too long been made the football of politics. Real progress cannot be had until the health office is divorced from the political influences as they exist in many of our cities and states to-day. We welcome the milk problem in politics — so far as that may be necessary to obtain legislation; but we must insist that the administration of the laws must be strictly non-partisan.

Value of the milk industry in the United States

Few people realize that the milk industry ranks among the first when judged in dollars and cents. Mr. Rowl, chief of the Dairy Division of the Bureau of Animal Industry, writes me that in 1910 there were 22,774,033 milch cows in the United States. The average value of a milch cow is $40.49. Therefore the total value of the milch cows in the United States is approximately one billion dollars.

The annual average production per cow in 1900, including the city cows, was 3670 pounds of milk. This makes a total milk production in the United States of approximately ten billion gallons, a lake large enough to float the navies of the world. The average per capita consumption of milk in the United States is estimated at 0.6 of a pint daily. Since the present population of our country is 93,402,151 persons, the amount of milk as such consumed annually would be approximately two and one half billion gallons. Only about one quarter of the milk produced is consumed as such; the remaining three quarters goes mainly into butter and cheese. The average dairy cow gives about enough milk to supply fourteen persons, provided it is all used as milk. The country over, there is one milch cow for every four and one half persons.

According to the census of 1900 the average farm price for milk was 8.7 cents per gallon. The figures for 1910 are not yet available; when obtained, they will doubtless be

somewhat higher than this. At the price stated the total value of the milk produced in the United States is about eight hundred and fifty million dollars a year.

Milk an emblem of purity

Milk everywhere and always has been held up as an emblem of purity. The fact that it is the sole food for babies during the first few months of life, its bland nature, and wholesome character, lend countenance to this belief. Its very whiteness helps to give it a good character. It therefore comes as a shock to know that the pure whiteness covers dark dangers and that the land of milk and honey may be a valley of death and disease.

There are a number of reasons why milk is sometimes harmful. The way we use milk to-day is an artificial practice, if not an unnatural one. When we go against nature we must suffer the consequences. Nature never intended the milk of one animal to be used by the young of another. It is further quite evident that nature intended the milk to be partaken of while fresh at the fountain of its production. To separate the mouth of the baby from the teat of the cow by several hundred miles is often a serious matter for the baby, — for in the mean time the milk has deteriorated and may have assumed dangerous properties. Many factors besides time, temperature, and bacteria hasten the deterioration or influence the quality of the milk, such as handling, aerating, straining, clarifying, separating, mixing, transporting, bottling, and various sundry processes that will be dwelt upon later on. All this may profoundly modify the very nature of the milk. Dirt and bacteria enter, decomposition proceeds, poisons may develop, so that a glass of ordinary market milk may be very unlike the food that leaves the mammary gland. We shall soon learn that bacteria love milk. They love it as much as the baby does. Milk is a perfect food for the growth and development of germs. They grow in milk at

a prodigious rate, and hence the danger is sometimes very great.

Familiarity has dulled our senses even to the ethical side of the milk question. Milk and questions concerning its production are discussed in the parlor before young girls just as frankly as we speak of the weather or the latest styles. The fact that milk comes from the mammary glands and is one of the secondary results of pregnancy are scarcely realized by many city people, who only see milk as it is served to them on the dining-room table. Equal frankness with questions of sex hygiene and the venereal peril would help solve these perplexing problems.

Times and conditions have changed

One frequently hears the remark: "Look at me; I am hale and hearty at threescore and ten and have always been fond of milk and taken it just as it comes, dirt, bacteria, and all." Such persons forget three very important things. The first is that the fruits of victory are not to be judged by the survivors alone. We must have a roll of the killed and wounded too. The sanitarian so often hears the argument, "Look at me; it has not hurt me," that it is beginning to tax his patience. If the health officer wants to close an infected well, the grandfather points with patriarchal pride to his hale old years and hearty health as proof that the water can do no harm. We hear the same thing when it is proposed to purify or filter the water of a polluted stream. Only last winter, during the epidemic of typhoid fever in ———, the mayor of that city used this very argument. I once heard a mother of four children (all that remained of ten) say, "Well, you cannot expect to raise them all." But we do expect to raise them all nowadays, especially if they can be nurtured upon fresh, clean, and safe milk.

The second important thing which old folks seem to forget is that conditions have greatly changed since they were young. Then the milk was wagon-hauled to town and

used the same day while fresh. Now it comes through many hands and is often about forty-eight hours old when it reaches the household. Finally, in the old days many a milk-borne outbreak occurred, many an infant met an untimely death through impure milk, but the dangers were not known and therefore not realized. The affliction was attributed to sewer-gas, to miasms from the soil, or some mysterious agency, if not the will of Divine Providence. The milk has not changed so much since the good old times, but our knowledge has.

The dangers in milk lack dramatic interest

The milk problem, like many another problem in preventive medicine, lacks dramatic interest. The tragedies that fill the front page of our newspaper, that we read one day and forget the next, are not the real tragedies of life. Tuberculosis in one year claims more victims than the number killed by bullets in the four years of our Civil War. In our fair land 160,000 persons die annually from tuberculosis alone. Of the 90,000,000 persons now living in the United States, about 6,000,000 are doomed to die of the "great white plague." The death toll from typhoid fever in the United States is 25,000 lives annually. Over 250,000 persons suffer from this preventable infection each year. I mention only two instances, and select tuberculosis and typhoid fever because they are diseases sometimes spread by infected milk.

It is much more theatrical to cure a disease than to prevent its occurrence. To stamp out an epidemic seems to some flamboyant minds a more notable achievement than to prevent its occurrence. When disease is prevented, nothing happens. There is a lack of action. There is nothing to fill the eye, but the ounce of prevention is still worth much more than the proverbial pound of cure.

It is so with milk. Good, clean, safe milk gratifies the palate, satisfies thirst and hunger, and produces no un-

THIS WAS AN EDUCATIONAL PLACARD DISTRIBUTED TO VISITORS AT THE PHILADELPHIA MILK SHOW HELD IN 1911, AND PUBLISHED UNDER THE PATRONAGE OF THE RUSSELL SAGE FOUNDATION

The motto of the Philadelphia Milk Show was, "To ENLIGHTEN, not to FRIGHTEN." The cartoon illustrates vividly the contrast between dirty, infected milk, and clean, wholesome milk. Such illustrations sometimes have the unhappy effect of deterring people from using milk at all. Our object is to discourage the use of poor milk — encourage the use of good milk.

toward effects. Infected milk may cause disease and death a week, a month, even a year or more afterwards. The connection is not clear to persons who have not given the matter careful consideration, and is therefore shrouded in mystery and no little skepticism.

Babies are killed with milk in an insidious way. If, instead, the babies should be scalded to death in boiling milk, the incident would have the elements of human interest for the newspaper reporter.

For these reasons the dangers in milk do not strike the popular imagination. The effects of prevention seem obscure and negative. — The results of cure are evident and positive. This is one of the handicaps from which prevention suffers. If Jenner had discovered a cure for small-pox, and if that cure were only half as effective as vaccination, every civilized country in the world would do him homage.

The need of patience — slow but sure progress

It is perfectly plain to anyone who has made a special study of the milk supply for large cities that nothing short of a social and economic revolution will give us an immediate approach towards clean, fresh, and safe milk for the "inmates" of our large cities. The difficulties are so perplexing that even idealists have said to me in private conversation that they consider that the milk question will never be solved. I take no such pessimistic view. I know the difficulties, and I know the end will be slow in coming, but it is attainable and will be reached. It cannot be done by spasmodic and sensational attacks upon the contractor, the farmer, or the milk driver, which in some cities seems to be part of the day's fun. Newspaper campaigns sometimes confuse, often react, and thus may actually impede rather than help the final solution. Real progress in this case can only be achieved through patient, well-considered, and persistent effort that will gradually give us what we want; namely, clean, fresh, and safe milk.

In this regard the milk problem does not differ from other problems in preventive medicine. We know that tuberculosis, for example, will not be conquered in a generation, although we now have the key to unlock the door. The modern message in tuberculosis is that it is preventable and curable, but the fact that it is preventable does not mean that it will be eliminated next week or next year. We know that sanitoria, special hospitals, out-door camps, education, prevention of spitting, good food, fresh air, and all the rest are slowly making progress against the disease, but statistics do not show and will not show for a long time a very notable decrease in the amount of consumption. The reason for this is that knowledge alone is not sufficient. Science may point the way, but it remains for society to apply the teachings of science. Tuberculosis has become a social and economic problem. The disease is now a class disease; that is, the rich man can purchase health and immunity. He can afford to buy good food, pure milk, fresh air, sunshine, rest and recreation. He can select his employment and govern his surroundings to a large extent. He can employ help and take measures which keep him out of the danger zone. The poor man must accept conditions much as he finds them. Education is a good thing, but it is my observation that it is not necessary to teach people to eat good food, to breathe fresh air, to take plenty of rest, and to improve their surroundings. People do not as a rule remain in tenements huddled together in filthy, ill-ventilated rooms from choice. It is a matter of common observation that almost as soon as such people can afford it they purchase better housing conditions, take trips to the country and shore, and the second generation soon outstrips the old folks in cleanliness, comfort, play, and self-indulgence. Hence the sanitarian regards the man who increases wages or who shares his profits equably with his employees as a practical philanthropist of the best type.

The sanitarian can see the possibilities so clearly that he

is keenly eager to establish sanitary reforms at once. The hard knocks of experience, however, soon teach him that he must make haste slowly. The aggressive health officer who is a natural leader and can command a following is a blessing for any community. The most efficient health officers are those who apply the teachings of science in a systematic and practical manner and who insistently and persistently improve the sanitary conditions of their districts and then help the people to help themselves. This is the sort of efficiency that is needed to help solve the milk question.

The dangers from milk and water contrasted

The great difference between milk and water from a sanitary standpoint is that bacteria tend to die in water whereas they grow well in milk. It is well known that water has a tendency to purify itself. Running streams become cleaner. Thus the Mississippi River, after draining thousands of miles of inhabited territory, and receiving the sewage of several million people, is relatively pure as it flows by the doors of New Orleans. The storage of water in ponds, lakes, or reservoirs, where in time the harmful bacteria die, is one of nature's sanitary safeguards.

It is otherwise with milk. Bacteria grow even more quickly in milk than they do in the body. Typhoid and diphtheria bacilli multiply at prodigious rates. Under ordinary circumstances the tubercle bacillus probably does not multiply in milk, but will remain active and virulent for months. Streptococci and other harmful varieties increase manyfold in a few hours.

Dilution, sunshine, aeration, sedimentation, and other factors, which are unfavorable to germ life in water, have no chance in milk. Clean water does not furnish sufficient food even for the humble germs. Milk, on the other hand, is a rich culture medium. Therefore, whereas a little infection may be lost, diluted, or soon disappear in water, a little infection in milk may increase and seriously contaminate a

whole supply. It requires only a spark to start a conflagration.

Formerly the attention of sanitarians was directed very largely to the water as the source of typhoid fever and other diseases. Now that the water supply of most of our large cities is in a fairly satisfactory condition, milk is taking the place of water in the minds of health officers.

It is more than a mere figure of speech to say that a river of milk flows from the country into the city. This river rises at the udder of the cow and flows into the mouth of the consumer. It is a long thin stream with many tributaries, and there is much mixing and intermingling of the various supplies. Thus some of the contractors handle over a hundred thousand quarts of milk a day, much of which is mixed in large vats resembling enormous bathtubs.

This white river of milk collects dirt and foreign matter, from its drainage basin and along the course of its flow, which is sometimes several hundred miles. It picks up infection, too, and in this way disease is transported from the country to the city. There is an interchange of courtesies in this regard, for, as we shall see, the germs of disease are sometimes sent back to the country in the empty cans and bottles.

The size of this white river surprises those who have given the subject little thought. For instance, New York City uses 1,600,000 quarts of milk a day. This represents only about one third of a quart for each person per day. Twice this amount is used as butter, cheese, and other milk products. More milk is used throughout the northern part of our country than in our southland. In the tropics still less is consumed, because it is exceedingly difficult to keep the milk for any length of time, and on account of the scarcity of ice, fresh milk is not an article of common use as it is with us. In Japan, China, and some other countries cow's milk is not used at all.

Sedgwick draws the contrast between milk and water as follows: —

It should never be forgotten that if water were to be drawn, as milk is, from the body of a cow standing in a stable, by the hand of workmen of questionable cleanliness, and then stored and transported over long distances in imperfectly cleaned, closed cans, being further manipulated more or less, and finally left at the doors at an uncertain hour of the day, few would care to drink it, because its pollution and staleness would be obvious. It is clear, moreover, that it [milk] requires and deserves more careful treatment than water, for it is more valuable, more trusted, and more readily falsified or decomposed.[1]

Education

Ignorance and apathy are obstacles in the way of improving the milk supply and diminishing the dangers. Still further to confuse an already complicated situation we have the fact that the milk question is an unusually difficult and perplexing one. To fathom all its phases requires a competent knowledge of bacteriology, chemistry, pathology, economics, sociology, animal husbandry, vital statistics, the veterinary and medical sciences, as well as a number of kindred subjects. Education, therefore, is one of the principal spokes in the wheel of the milk wagon. A little knowledge may be doubly dangerous in the milk question and it is responsible for many ill-considered laws, drastic regulations, and impractical requirements that are asked of the farmer, the common carrier, the dairyman, the contractor, and the health authorities. It is easy enough to demand an ideal, but it is often difficult to obtain and establish improvements that lead towards the ideal. It is so with the milk situation. By education we do not simply mean superficial information. It includes a deeper insight

[1] Sedgwick, *Principles of Sanitary Science and the Public Health.* New York and London, 1902, p. 279.

into the milk problem, based upon experience and fact. We must remember that the subject is comparatively new, and that even the medical profession is not fully alive to the meaning and significance of many important facts in the milk question. Few medical schools teach their students the art of dairying and the relations of milk to health and disease.

The subject is of sufficient importance for educators to consider its introduction into the lower school grades. Even young children may learn how to make butter from milk; they may observe the facts concerning the souring of milk, and may make simple observations upon milk which have an important and fundamental bearing in biology, chemistry, bacteriology, and other subjects. The sight of a drop of milk under the microscope is a revelation, and the childish mind is stimulated by such an exercise. The subject of clean milk touches almost every question in modern sanitation and will prove a valuable object lesson for the growing mind. It is also good pedagogy to take children and grown-ups upon excursions to see dairy farms, dairies, and milk laboratories.

Education through moving-picture shows, illustrating the effects of dirty milk, serve a useful purpose. Newspaper items, public health prints, sanitary tracts and lectures, all help to spread the good word.

Education alone is not sufficient. The milk problem also needs conscientiousness. To guard against the lapses to which human nature is liable demands official supervision.

The object of education is to enlighten, not to frighten. Public educators sometimes make the mistake of painting the dangers in glaring red and bloody letters. To such, all bacteria have a black hand. A timid person is unduly frightened, and if conscientious, approaches his task with fear and trembling, realizing that he is living over a volcano and that the health and lives of his fellowmen are at stake. A wholesome fear is a good stimulus; a good conscience on

the part of the producer will often furnish us a better milk than can be obtained through the prodding of board of health inspectors.

The following course of events is not an unusual one: A careful and conscientious individual enters the milk business fully alive to the possibilities. He is painstaking, and scrupulously puts into practice all that has been taught him. One day something goes wrong; a slip occurs; the milk nevertheless is sent to market and is consumed as usual. Nothing out of the way takes place; no one gets sick; no one dies as a consequence. This little experience naturally makes the individual think that the dangers have been exaggerated. Time wears on and other lapses occur; again without direful consequences. Conscience is thus dulled and there is now danger of going to the other extreme, namely, underrating the danger. Slipshod methods may go on without menacing health or life for years, but some day the catastrophe occurs. The volcano gives no warning of its eruption.

Coöperation

Competition is not the life of trade in the milk industry. Competition accounts for a certain amount and kind of "life" in milk — namely, bacterial life. In other words, commercial competition hurts the quantity and the quality of the milk supply. Coöperation is the watchword.

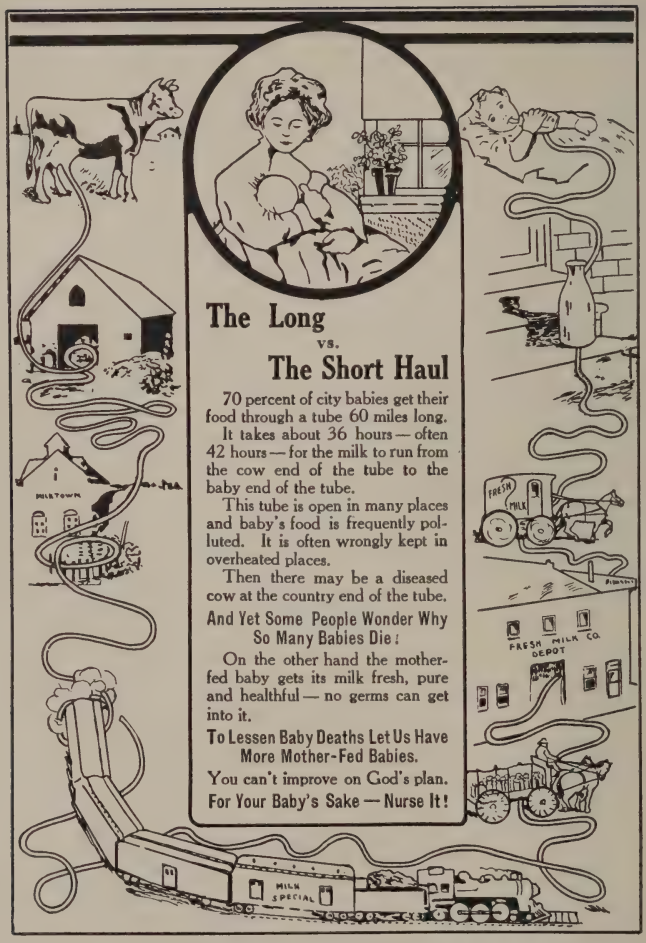
In every discussion of the milk question, either at national, state, or local societies, at farmers' granges, at scientific meetings, etc., one thing is unanimously urged and that is coöperation. Even the Federal Government approves and insists upon coöperation as one of the necessary reforms in the milk industry, but as soon as the dairymen get together an action is brought against them for combination in restraint of trade; even the same thing has taken place with the farmers.

There are good and bad combinations. Thus the attorney-general of the State of New York showed that a combination existed among the milk dealers of New York City. At the same time the investigation also showed that the producer was paid less than the cost of production and that the consumer was charged an excessive price.

How much may be accomplished through coöperation has been shown at Montclair, New Jersey. There, through the example of Mr. Stephen Francisco and Dr. Coit, working hand in hand with efficient health officers, the quality of the milk has been greatly improved and the number of bacteria lessened. The incompetent producers have retired from the field and the price of milk has been raised to ten cents. This furnishes a notable instance of intelligent cooperation and shows what can be done by persistent effort and eternal vigilance. Much has also been accomplished through the right kind of coöperation at Rochester, New York; at Fall River, Massachusetts; at Richmond, Virginia; at Boston, Massachusetts; at Geneva, New York; and other places.

Thirty years ago Denmark set the example and showed the world how much practical progress may be achieved through intelligent and honest coöperation. Denmark is a farmers' country and there the farmers rule. In most of our states the farmers are in the minority, but an indispensable and powerful minority. They could accomplish quite as much for themselves and for the consumer through wholesome coöperative methods as has been accomplished in Denmark.

Those who have had their early morning sleep disturbed by the rumble of six milk wagons on the block, when one could do the work, will appreciate one phase in which cooperation would be of service. Take the case of pasteurizers. It is evidently cheaper and better to have one large pasteurizer under skilled supervision than to have fifty


The Long
vs.
The Short Haul
70 percent of city babies get their food through a tube 60 miles long.
It takes about 36 hours — often 42 hours — for the milk to run from the cow end of the tube to the baby end of the tube.
This tube is open in many places and baby's food is frequently polluted. It is often wrongly kept in overheated places.
Then there may be a diseased cow at the country end of the tube.
And Yet Some People Wonder Why So Many Babies Die!
On the other hand the mother-fed baby gets its milk fresh, pure and healthful — no germs can get into it.
To Lessen Baby Deaths Let Us Have More Mother-Fed Babies.
You can't improve on God's plan.
For Your Baby's Sake — Nurse It!
MILKTOWN
FRESH MILK
FRESH MILK CO. DEPOT
MILK SPECIAL

This illustration, taken from the Weekly Bulletin of the Chicago Health Department, is an admirable type of cartoon. It is instructive yet excites no unpleasant sensations. It enlightens but does not frighten. It illustrates very well many of the fundamental problems in the milk question, and is so graphic that he who runs may read the moral.

pasteurizers working but part of the day with fifty sets of employees and fifty different inspections. There is not only an economic advantage in the production, transportation, handling, and distribution of milk through coöperation, but there is also a hygienic safeguard, as will be shown further on.

The final solution of the milk problem will require mutual coöperation between the farmer, the consumer, the middleman, the health officer, the transportation agent, and the legislator, in order to achieve real, constructive progress.

The harm of exaggeration — truth is mighty and will prevail

There is a temptation on the part of the popular exponents of science toward overstatement. When all the indictments are brought together we find that milk is an enormous criminal. The dangers are real enough and bad enough without the need of exaggeration. The facts speak for themselves. There is need of moderation. The statement is often made that danger "lurks" in milk. This is quite true, but every portion of milk is not a potion of poison. Experience teaches us how to read human nature and distinguish between the good man and the bad man in this world. But no amount of experience would ever help us to distinguish between a glass of good milk and a glass of infected milk, for they may look alike, taste alike, smell alike. In other words, while milk is the most innocent-looking, it may occasionally be the most dangerous of foods.

After a discussion upon the subject of bacteria in milk we often hear it said, "The wonder is that any of us are alive." As a matter of fact, one of every four or five of our babies perish before they are able to walk or talk. This is not all due to milk, but some of it is. The plain fact is that some lives might have been prolonged by the avoidance of dirty or infected milk.

Infection flows from the country into the city

We have just said that infection flows from the country into the city. This occurs not only in the milk, but in the water and other articles of food. Cities are fast beginning to learn that even with beautiful parks and boulevards, clean streets, and similar ideal conditions, the health question is only half solved. No city can remain healthy unless it takes into account the health of the country from which it obtains its food supply. This refers especially to the sanitary conditions of the surrounding territory which furnish it with fresh materials commonly consumed raw, among which the most important is milk.

It is interesting to note at this point that at one time there was much more disease and a much higher death rate in the city than in the country. The tables have now been turned, for there is less chance of contracting infection in a well-ordered city than in the average country place. The reasons for this are plain. For a long time people did not know how to live huddled together in large communities. The sanitary sciences were in their dark ages. Every man was his own sanitarian. Fads and fancies ruled the day in matters hygienic. In cities people partook of polluted water without a qualm. In fact, it took people a long time to find out that the inexpressibly nasty habit of drinking water defiled with sewage was dangerous as well as not nice. The wastes from human life were not properly and promptly disposed of. It is only in comparatively recent years that water-closets, and the exceedingly satisfactory system of water carriage for the prompt removal of sewage and kitchen waste has supplanted the old privy and sink. Formerly, organic matter was allowed to collect about the premises in which rats, flies, and other vermin bred and fed. In fact "man lived on a dung hill." This has been partly corrected and each householder should now consider it part of the day's work to clean up his

own back yard and cellar. Formerly people did not understand the value of fresh air and good housing. A contagious disease introduced into such unsanitary conditions was like a spark in dry brush. The prairie was soon afire and conflagrations in the shape of epidemics were all too frequent. Many diseases, such as leprosy, typhus fever, and famine fever, were then constantly smouldering in the large cities and often broke out as devastating epidemics. Now such diseases are practically unknown in clean communities. These changes for the better have come about through cleanliness and the application of the teachings of the sanitary sciences.

Almost all our larger cities now have a fairly satisfactory and clean water supply. The removal of wastes is steadily showing improvement. Sanitary cleanliness is extending from our parks and boulevards into alleys and rookeries. Modern sanitation is very expensive and large cities can better afford the outlay than small villages or isolated country places. It is evidently an economic impossibility for each farmhouse to have a sanitary water supply and have a safe system of disposal of its wastes under expert advice such as the city enjoys. Herein lies one of the great powers for usefulness of the state and county health officer. The sanitarian now realizes that the next point of attack is the country.

There is still one weak spot in the city over which the country has a decided advantage and that is the milk supply. In the country it is easy to obtain fresh milk twice a day. The dweller in a large city is fortunate if he gets milk less than forty-eight hours old. Milk when it reaches the consumer in the city is often very different when compared to the same milk used on the farm. The farmer cannot understand why it is that the milk agrees with his baby, but makes the city baby sick. He forgets that the milk he sends to the city is often placed in dirty cans, perhaps rinsed with infected water or mopped "clean" with soiled cloths.

The cans are often placed on the farm wagon and carted several miles to the nearest railroad station, where they stand some time in the sun and occasionally are exposed to dust, flies, and prying fingers of irresponsible persons. After this they are loaded on the milk car, which is perhaps warm. Arriving in the city, the cans again stand around the milk platform waiting for the city wagon, when they are carted to the city dairy. Here they are opened, the milk is tasted and smelled, and poured into a large vat, where the contents of the can is mixed with the milk from numerous other cans. From this vat the milk is pumped to a clarifier, where much of the dirt and slime is removed. From there it may pass through other processes before it is cooled and bottled. The bottle may not have been properly cleansed and sterilized. This bottle is placed upon a wagon and carried to the householder, who thus receives milk that is several days old, has been frequently handled, has come in contact with a number of different containers and machines, and has had a good chance to deteriorate as well as to collect various kinds of dirt, with the possibility of picking up infection. City milk, stale, dirty, and bacteria-laden, is therefore a very different article from the fresh country brand.

The farmer further forgets that his child has a greater resistance to infection than the city child. Reared in God's sunshine, with plenty of fresh air and under natural conditions, it can cope with dangers that may be fatal to the pale, flabby tenement baby.

Where the blame lies

There is a tendency on the part of the consumer to blame the producer. On the other hand, the producer blames the consumer; whilst the middleman points an accusing finger at both the consumer and the producer. The health officer blames all three. This is an unfortunate state of affairs based upon ignorance of the real situation.

It causes an unnecessary amount of friction and engenders ill-feeling from a misunderstanding of the fundamental causes of the milk problem.

Society must blame itself; that is, we are confronted with a situation that has been evolved naturally as a result of the existing state of civilization. The milk question is simply one of the difficulties of a complex age — one of the difficulties of an artificial civilization to which we have not yet adjusted ourselves. It is part of the great sociologic problem which has arisen as the result of the crowding of great masses of humanity in centres of population. The proper feeding of our metropolitan centres, with their increasing demands and exactions of palate and purse, taxes the ingenuity of the farmer, the transportation agent, the middleman, and the retail distributor. The milk question is part of this great problem. No one group of persons is to blame. We are simply suffering the inevitable penalties we must pay for modern conditions of life.

The question, then, is to be met frankly and manfully as one of the problems of the times and in an entirely impersonal sense. It helps nothing and harms much to point the finger of accusation at an innocent person. Of all those concerned the farmer is least to blame for the situation as it exists, and the consumer in the city should be ever mindful that he has rather brought the conditions upon himself. The ultimate solution of the problem will depend upon coöperation and a constructive spirit of progress in which all hands join.

In one sense the milk question is not a modern question. It must always have been present from the time milk became an article of commerce. It is simply more apparent to-day because science has focused the searchlight of truth directly upon it. If anyone is to be blamed, therefore, it is the scientists who have made the discovery that diphtheria, scarlet fever, typhoid fever, tuberculosis, and other diseases are spread by milk and that stale, warm, and bacteria-

laden milk is especially dangerous to young infants; and the discovery that some widespread epidemics which were formerly attributed to water, air, and other causes are, in reality, due to milk. The scientist has the satisfaction of knowing that while he has pointed out the dangers he has also pointed out the means by which they may be prevented, — and in some instances cured.

CHAPTER II

MILK AS A FOOD

MILK contains all the ingredients needed for nourishment. Further it contains these ingredients in just the right proportion which experience and science show should be contained in a well-balanced ration. Thus it contains proteins, which furnish the materials which build up the body and keep it in repair; and it contains fats and carbohydrates, which are the fuel to keep the body warm and furnish it with the power needed to do its work. Further, it contains the necessary amount of water needed by the body and also the inorganic salts, without which life cannot continue.

It has been figured out by government experts that about sixteen per cent of the ordinary American diet consists of milk or milk products. These figures are evidence of the very important place milk has in our dietary even for adults.

It is ofttimes said that milk is a perfect food. This statement is somewhat misleading, for while milk is a perfect food for the suckling it does not necessarily meet all the demands of the adult. It is true that it contains all the required elements for the growth and maintenance of the young mammal, but it lacks certain properties which make it suitable as the sole nourishment of the adult individual. In fact, milk is too perfect a food for the adult. Every portion of it is used. There is no waste or indigestible refuse, which appears necessary for the normal action of the digestive tract.

The statement that milk is an essential article of diet also needs qualification, for the Japanese manage to get along pretty well without it. There, the babies are nursed by their

mothers somewhat longer than in this country, and are weaned gradually upon a farinaceous and miscellaneous diet. China and other countries also get along without the use of milk.

Furthermore, milk contains more protein than the adult requires. The average man needs about three thousand four hundred calories a day, but the milk which would provide that much energy would contain 0.34 pounds of protein. A moderately active man of average build does not need more than 0.28 pounds of protein daily. Therefore an adult upon a milk diet somewhat approaches the person eating too much meat.

Again, milk is a rather dilute food for adults, so that it would be necessary for a man to drink at least four or five quarts daily to obtain sufficient nourishment from it. A quart of milk contains in all about four ounces of nutriment. This is the same amount found in three fourths of a pound of beef or six ounces of bread. But while the quart (two pounds) of milk, the twelve ounces of beef, and the six ounces of bread all supply like amounts of nutriment, the nutritive values are not exactly the same; that is, they would not be equally useful as food. Thus the beef is rich in proteins and poor in carbohydrates; bread is rich in carbohydrates and poor in proteins and fat; while milk contains proteins, carbohydrates, and fats in just about the proportions needed in a well-balanced ration.

When compared by weight with other articles, the food value of milk does not seem to be high because milk consists of such a large proportion of water (about 88%). When, however, the portions ordinarily served at meals are considered, the high worth of milk is clearly shown. The food value of one half a pint of milk is approximately equal to two large eggs, to a large serving of lean meat, to two moderate-sized potatoes, to five tablespoonfuls of cooked cereals, to three tablespoonfuls of boiled rice, or to two slices of bread.

It is commonly stated that one quart of milk is about equal in food value to any one of the following: —

2 pounds of salt codfish.
3 pounds of fresh codfish.
2 pounds of chicken.
4 pounds of beets.
5 pounds of turnips.
$\frac{1}{6}$ pound of butter.
$\frac{1}{3}$ pound of wheat flour.
$\frac{1}{3}$ pound of cheese.
$\frac{3}{4}$ pound of lean round beef.
8 eggs.
2 pounds of potatoes.
6 pounds of spinach.
7 pounds of lettuce.
4 pounds of cabbage.

These comparisons are somewhat misleading. We cannot compare foods upon a basis of their total caloric value alone. It is very much like feeding a boiler. We might shovel good anthracite coal into a furnace built to consume coal-oil or bituminous coal and not get good results. Digestibility and assimilation must be considered as well as chemical composition and caloric value.

The following table prepared by my assistant Dr. Harold L. Amoss, gives instructive comparisons between milk and some other standard articles of diet.

	Price per pound	Cost of 1 pound protein	Cost per 1000 calories	Amount for 10 cents				
				Weight lbs.	Protein lbs.	Fat lbs.	Carbohydrates lbs.	Energy calories
Beef	$0.25	$ 1.60	$0.25	.40	.06	.06	....	410
Oysters	.25	4.30	1.11	.40	.02	....	.01	90
Butter	.20	20.00	.06	.50	.01	.40	....	1705
Eggs	.24	2.09	.39	.42	.05	.04	....	260
MILK	.035	1.09	.11	2.85	.09	.11	.14	885
Cheese	.16	.64	.08	.63	.16	.20	.02	1185
Oatmeal	.04	.29	02	2.50	.34	.16	1.66	4500
Wheat Bread	.06	.77	.05	1.67	.13	.02	.87	2000
Beans — Dry	.05	.29	.03	2.00	.35	.03	1.16	3040
Potatoes	.015	1.00	.05	6.67	.10	.01	.93	1970
Sugar	.06	....	.03	1.67	....	....	1.67	2920

Physiology of lactation

The mammary glands are included among the glandular structures of the skin. The other skin glands are the sweat glands and the sebaceous glands.

In the young mammalian embryos generally the mammary glands develop from the ectoderm and are first indicated by a thickened line of the deeper layers of the skin. This thickened line extends from the armpit to the groin. Later, much of this line disappears, leaving a succession of nodular thickenings corresponding with the nipples. In some mammalians this row of nipples remains; in others only the inguinal thickenings, as in the cow; and in still others only those towards the axilla. Thus in man there is normally only one nipple on each side. At birth the nipple is everted and at that time the glands in either sex may discharge a little milky secretion similar to the colostrum which precedes lactation. The glands grow in both sexes until puberty, when those in the male atrophy and only the main ducts persist. In the female, enlarged terminal alveoli become evident in pregnancy, when they develop into mature and fully formed mammary glands capable of producing a sufficient quantity of milk.

The circumstances which regulate the position and number of milk glands in animals depend upon the conditions of life, the manner by which the animal takes its food, the position of the animal in rest and action, the form of the thorax, the number of the young, and the way in which the mother holds the young, as well as the chances of injury to the glands, etc.

In those mammalian animals which bring into the world a large number of young at the same time the milk glands lie in two symmetrical rows on both sides between the armpits and the groin. Thus the Madagascar tenrec (a small insectivorous animal resembling the hedgehog) has twenty-two pairs of nipples. The domestic pig has four to eight;

the wild pig four to six pairs. In animals such as man and apes, with free upper extremities capable of carrying their young in the arms, the glands are situated on the upper part of the thorax. The same is true of the bat, sloth, and other animals in which the front extremities are relatively highly differentiated.

In most quadrupeds the mammary glands are suspended from the abdomen. Here the mammary glands are in a single pouch of skin known as the udder. The udder may contain from one to three teats on either side. In the cow, which interests us especially, the udder contains four separate mammary glands and four teats. They are usually spoken of as the four quarters of the udder. Each quarter is separated by a fibrous partition from its neighbors, and, as we shall see later, each quarter is largely independent. Thus one quarter may dry up while the other three remain functionally active; one quarter may be diseased while the others may remain healthy. Tuberculosis frequently affects one quarter of the udder, and the common inflammations of the udder known as garget are often limited to one quarter.

The human mammary gland when fully developed has the following structure: It consists of about twenty lobes separated from each other by connective tissue partitions. These lobes are again divided into a larger number of lobules, and these in turn are composed of numerous irregular round or oval or even tubular alveoli. The alveoli are provided with small excretory passages which unite to form the smaller ducts, these in turn uniting to form the larger ducts.

The mammary gland, in other words, resembles a bunch of grapes, and is therefore known technically as a compound racemose gland. Each grape corresponds to an alveolus. The alveolus is the milk factory. The stem to each grape represents the little duct which conducts the milk from each alveolus to the large stem or main duct through

which flows the milk from all the little alveoli to the nipple.

The alveoli are the true functional structures of the gland — that is, the part where the milk is secreted. The alveoli are lined with epithelial cells which, in a state of rest, consist of a single layer of cells, nearly cubic in shape. When the gland is ready to secrete milk the fat globules make their appearance in the distal ends of the cells: at the same time a corresponding increase in size occurs throughout the entire alveolus.

The exact manner in which the milk is secreted is not definitely known. There are, as yet, current two quite contradictory views as to the manner in which milk is formed. According to certain observers the free ends of the cells which contain the most fat globules are constricted off, which sets the fat globules free in the lumen. The secretory portion of the alveolus is then composed of low epithelial cells in which the process begins anew. According to this view the process of milk secretion, therefore, consists in throwing off the inner halves of the cells containing the fat globules. After this occurs, the cells regenerate themselves from the nucleated remains of the glandular epithelium. There is some doubt whether the nucleus divides or not during this process, and of course there is no way of knowing how often the process of regeneration may be repeated in a single cell. It is certain, however, that entire cells are destroyed, to be replaced later by new ones. Other observers regard the secretion of milk as occurring without partial or total destruction of the secretory cells, but after the manner of the secretion of other glands. This latter view seems more in accord with recent observations.

Although the exact mechanism of the production of milk is not known, certain facts are perfectly clear: The milk is formed from the blood. It is the epithelial cell in the alveolus which takes the materials from the blood and transforms them into milk. The little epithelial cell is a very

active factory. It takes the fat, the sugar, the albumin, the salts, and other vital elements from the blood and materially changes their physical and chemical nature. Thus the fat is gathered together into little droplets. The sugar is transformed into lactose, which is found nowhere in nature except in milk. The albumin of the blood is transformed into casein, which is also peculiar to milk. Just as a factory receives the raw products at the back door and delivers the fully formed articles ready for use at the front door, so each little cell receives from the blood certain "raw" products and transforms them into milk. These glandular cells are tremendously active during lactation and soon wear out or die. Large numbers desquamate; that is, they leave the basement membrane of the alveolus to which they are but loosely attached. These cells appear in great numbers in normal milk.

During milk production there is an increased flow of blood to the gland in order to furnish the materials necessary to produce milk. During this congestion some of the white blood corpuscles or leucocytes may leave their capillaries, squirm into the alveoli, and force their way by virtue of an active amœboid motion between the secreting glandular cells, and thus leucocytes may also appear in the milk. The number of pus cells or leucocytes is greatly increased if the mammary gland is inflamed. The origin, nature, and significance of the cells in milk have considerable practical importance. In some cities milk containing more than a specified number of "leucocytes" is condemned, especially if associated with streptococci. This will be discussed later.

The principal question under dispute is whether the secretion of milk takes place as a result of a considerable destruction of cells and cell nuclei or not. Large numbers of cells appear in normal milk and the consensus of opinion to-day is practically unanimous in considering these cells for the most part as coming from the cast-off glandular

epithelial cells lining the alveoli. Normal milk has relatively few or no leucocytes: pathological milk may contain many.

Composition of milk

Milk is an enormously complex substance; being a mixture, a suspension, and a solution of the representatives of each one of the great classes into which foodstuffs are usually divided, namely, proteins, fats, carbohydrates, salts, and water. In addition to this, milk contains various ferments or enzymes; gases; and also antibodies, including protective antitoxins which doubtless serve a useful purpose. In short, milk contains all the elements necessary for the growth and development of the young animal. It is the only single article of food which is complete enough in itself to sustain life for a very long time.

The milk of different animals shows a general agreement in physical properties and composition. It contains essentially the same ingredients, but differs in the amount of these several constituents.

In its perfectly fresh state milk is a yellowish-white opaque liquid. The opacity of milk covers a multitude of dirt and bacteria, and other sins.

When allowed to stand for some time it separates into two distinct layers. The upper, lighter layer is called "cream" and consists of all the constituents of the milk, but containing an increased number of fat globules. The lower, heavier layer is white or bluish-white in color and is known as "skim milk."

Milk[1] is heavier than water, having a specific gravity ranging from 1.027 to 1.040; that is, if a quart of water weighs 2 pounds and $1\frac{1}{3}$ ounces, a quart of milk weighs from 1.027 to 1.040 times as much, or about 2 pounds and $2\frac{1}{2}$ ounces. Such wide differences as from 1.027 to 1.040,

[1] Unless otherwise specified milk is understood to refer to cow's milk.

however, are to be found only in the milk of certain individual cows. The specific gravity of the mixed milk from a herd falls somewhere between 1.028 and 1.034. If the specific gravity is either above or below these limits, it is always suspicious. If the specific gravity is high, it suggests skimming; if low, watering. Skim milk has a specific gravity of from 1.033 to 1.037.

Milk freezes at a temperature somewhat lower than the freezing-point of water (— 0.55° C.).

On account of the presence of dissolved salts of various kinds milk conducts an electric current. Koeppe, who investigated this question, concluded that in cow's milk 0.072, and in human milk 0.04 grammolecules (Molen) exist in the ionic condition. In other words, 58 per cent of the molecules in cow's milk are dissociated, while only 26 per cent of the molecules in human milk are dissociated.

The specific heat of milk has been determined by Fleishmann. For milk containing 3.17 per cent of fat he finds the specific heat to be 0.9457. This same author also determined the coefficient of expansion of milk by heat and found it to be greater than that of water between 5° and 15° C. According to Fleishmann milk shows no maximum of density above 1° C.

Milk is much more viscid than water. Thus at 0° C. the ratio of the intervals required for the delivery of the same volume of water and milk is 100 : 221.1; at 15° C. the ratio is 100 : 188.7; and at 30° C. the ratio is 100 : 169.0; that is, milk becomes less viscid as its temperature rises.

Perfectly fresh milk of carnivorous animals is, as a rule, acid in reaction. This is probably due to the carbon dioxide and phosphates. Human milk and that of herbivora is usually slightly alkaline when freshly drawn. Cow's milk is described as amphoteric; that is, it turns red litmus blue, and blue litmus red. On standing exposed to the air for some time, milk almost always becomes more or less acid in reaction in consequence of the conversion of the milk

sugar into lactic acid through the action of different bacteria. This acidity increases until finally enough acid is produced to cause the souring or curdling ordinarily observed.

Under the microscope milk contains fat globules as well as cells, and bacteria, and frequently foreign particles of great variety of form and size.

The following table is compiled from a large number of analyses of milk and milk products which have been made by chemists of the agricultural experiment stations and other investigators. The figures show the average composition of these materials. The table also includes, for purposes of comparison, the average composition of a number of other common food materials: —

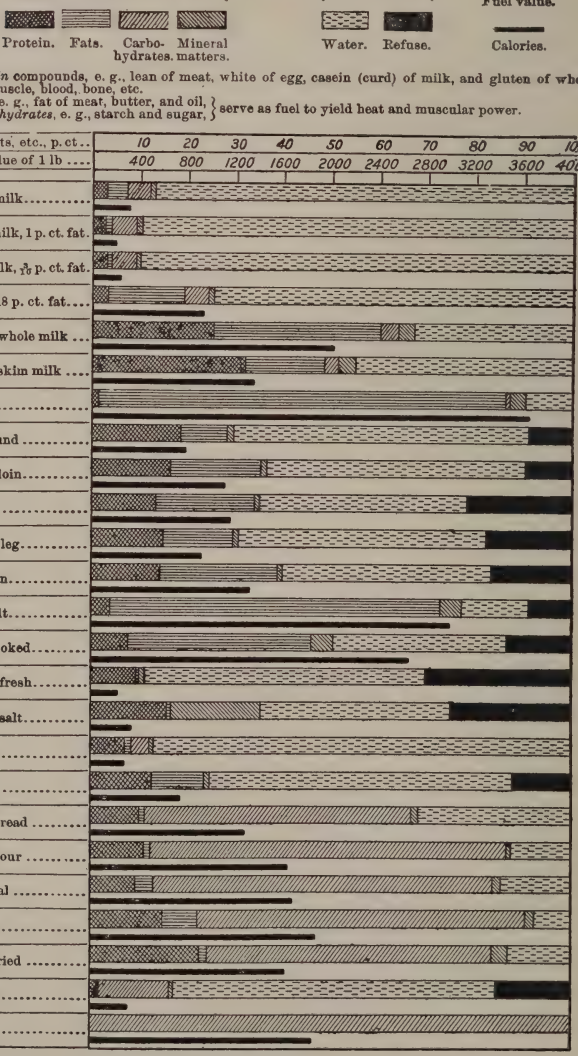
AVERAGE COMPOSITION OF MILK PRODUCTS AND OTHER FOOD MATERIALS

Material	Refuse Per cent	Water Per cent	Protein Per cent	Fat Per cent	Carbohydrates Per cent	Ash Per cent
Whole milk	....	87.0	3.3	4.0	5.0	0.7
Skim milk	....	90.5	3.4	.3	5.1	.7
Cream	....	74.0	2.5	18.5	4.5	.5
Buttermilk	....	91.0	3.0	.5	4.8	.7
Whey	....	93.0	1.0	.3	5.0	.7
Condensed milk, unsweetened	....	71.3	7.4	8.5	11.1	1.7
Condensed milk, sweetened	....	26.0	8.2	9.6	54.3	1.9
Butter	....	13.0	1.0	83.0	....	3.0
Cheese, American Cheddar	....	33.5	26.0	35.5	1.5	3.5
Cheese, cottage	....	53.0	19.6	23.2	2.1	2.1
Cheese, Swiss	....	31.4	27.6	34.9	1.3	4.8
Milk powder (from skimmed milk)	....	3.0	34.0	3.1	51.9	8.0
Kephir	....	89.6	3.1	2.0	4.5[1]	.8
Koumiss	....	90.7	2.2	2.1	4.1[2]	.9
Infant and invalid foods, farinaceous	....	9.4	9.4	.4	79.9[3]	.9
Infant and invalid foods containing milk and starches	....	4.3	9.6	3.8	80.2[4]	2.1
Infant and invalid foods, malted preparations	....	4.2	12.0	1.0	79.8[5]	3.0
Beef, sirloin steak	12.8	54.0	16.5	16.1	....	.9
Eggs, as purchased	11.2	65.5	11.9	9.3	....	.9
Wheat flour, patent roller process	....	12.0	11.4	1.0	75.1	.5
Wheat bread, white	....	35.3	9.2	1.3	53.1	1.1
Beans, baked	....	68.9	6.9	2.5	19.6	2.1
Potatoes, as purchased	20.0	62.6	1.8	.1	14.7	.8
Apples, as purchased	25.0	63.3	.3	.3	10.8	.3

[1] Including 2.1 per cent alcohol and 0.8 per cent lactic acid.
[2] Including 1.7 per cent alcohol and 0.9 per cent lactic acid.
[3] Including 6.62 per cent soluble carbohydrates (sugars).
[4] Including 49.05 per cent soluble carbohydrates (sugars).
[5] Including 43.39 per cent soluble carbohydrates (sugars).

COMPOSITION OF MILK AND OTHER FOOD MATERIALS [1]

Nutritive ingredients, refuse, and fuel value.



[1] *Farmer's Bulletin*, no. 363, U. S. Dept. of Agriculture.

Variation in composition

Cow's milk varies greatly in composition. No other organic foodstuff shows such a marked variation except meat. The greatest variation is shown in the butter-fat. The proteins and carbohydrates are more constant. This variation in composition of pure milk is due to a number of different factors, thus: Certain breeds of cows, such as Channel Island breeds, produce a milk rich in fat (about five per cent), while the Holstein stock furnishes a milk relatively poor in butter-fat (about three per cent). Young cows ordinarily produce richer milk than old ones of the same kind. In general a well-fed cow gives more milk and better milk than if poorly fed, but the quantity of the milk is more readily influenced by the amount and character of the food than are the relative proportions of fat, casein, and milk sugar. The milk flow of a given cow is usually largest soon after calving. As the period of lactation progresses, the milk flow gradually falls off and as a rule the milk grows richer in total solids. The proportion of fat to the total solids in the milk of a given cow varies from day to day and even from milking to milking. Therefore it is customary in good dairy practice to mix the milk of several cows immediately after it is drawn. In this way the consumer is assured a more uniform product from day to day.

Flavors and odors

The flavor of milk varies almost as much as its composition. Fresh, normal milk is sweet and agreeable and has a very faint animal flavor when warm; this is largely lost upon cooling. Formerly normal milk was supposed to have a "stably" odor, and fastidious persons have been known to reject a glass of clean fresh milk because it did not smell "cowy." A "cowy" taste in milk is often due to absorption of odors in the stable. The dirt that falls into the

milk also adds its quota. The cleaner the cow the less noticeable the flavor. A stable with a strong ammoniacal odor of decomposing cow dung is bound to assert itself in the milk. A clean stable or dairy will be free of odors. Many of the volatile flavors and odors in milk, whether normal or abnormal, may be driven off by aëration. This is a very common practice among dairymen.

Milk absorbs odors and flavors as readily as charcoal. If milk is exposed to tobacco smoke, to fish, to onions, to fruit, etc., it will soon be tainted. Turnips, onions, and other strong tasting substances fed to the cow will be perceptible in the milk; beet leaves or malt sprouts give the milk a burnt taste and odor. As an illustration of the great care necessary to keep foreign odors out of the cow barn mention is made of the case in Copenhagen where a dairy was disinfected with carbolic acid and the milk had a distinct carbolic acid taste for five days afterwards.

Upon standing, milk always develops, sooner or later, a sour, bitter, or putrid flavor. This is due entirely to bacterial action. In fact, bacteria are the common and also the most important cause of abnormal flavors and odors in milk. A sour taste indicates fermentation of the milk sugar; a bitter taste indicates putrefaction of the proteins.

The fat in milk has a distinctive taste and aroma, owing to certain fatty acids. This is more apparent in butter, where these substances are in greater concentration.

Chemical constituents

The chemical constituents of milk are chiefly water, proteins, fats, sugar, and inorganic salts, each of which will now be discussed separately.

Water. The chief constituent of milk is water. The milk of almost all animals contains from eighty-six to eighty-eight per cent of water. Some milk has normally more water than other milk. Thus the milk of whales is very concentrated and contains only fifty per cent of water.

The milk of Holstein cows is more dilute; that is, contains more water than the milk of Jerseys and Guernseys.

Fat. The fat is a very important but by no means the chief constituent of milk. Very many people think that fat is the only valuable part of milk, for the reason that the cream layer is so plainly in evidence, and so much emphasis has been laid upon the butter-fat standard. As a matter of fact, even the richness of milk cannot always be gauged by the cream line. The casein and milk sugar are not visible, but are just as important as the fat.

Fat occurs in milk in the form of an emulsion; that is, it is not dissolved in the milk as the sugar and salts are dissolved, but is suspended in the milk serum in the form of small droplets or globules. The fat is lighter than the milk and therefore, when milk stands, it rises and floats upon the surface just as pieces of wood float upon the surface of water. The fat rising thus to the top of the milk as a distinct layer is known as "cream" or "top milk."

Cream is obtained in two ways: When milk is allowed to stand, the top layer is known as "gravity cream," to distinguish it from "separator cream" obtained by centrifugation. The heavier portions of milk, that is, the water, casein, and sugar, are thrown as far from the centre as possible by the centrifugal force of the rapidly rotating machine and the lighter cream is thus forced to the centre where it can be drawn off. It takes at least twelve hours to obtain gravity cream, while separator cream may be obtained at once from perfectly fresh milk. Further, the fat can be separated by centrifugal force much more completely than by gravity.

Cream or top milk does not consist of fat alone, but of all the constituents of the milk. It is simply milk rich in fat.

Upon shaking milk or cream the fat globules gradually coalesce into larger drops, and these drops unite with other drops until lumps are formed — butter.

The fat in milk consists of a mixture of different neutral

fats, the principal of which are olein, palmitin, and stearin. These are neutral triglycerides of the corresponding fatty acids. Besides these are found the triglycerides of myrictic acid and butyric and caprolic acids. The last two are volatile and give to butter its characteristic odor and flavor. Milk-fat also contains traces of triglycerides of other fatty acids. The composition of the fat in various milks is subject to slight variation depending upon racial peculiarities and also upon the composition of the food and other conditions.

The fat droplets in milk are very tiny and can only be seen under the higher powers of the microscope. They vary considerably in size, but the average diameter is quite constant for each species. Thus the fat droplets from Holstein cows are considerably smaller than the fat droplets from Jerseys and Guernseys. It is as easy to distinguish Jersey milk from Holstein milk under the microscope, by the size of the fat droplets, as it is to distinguish these distinctive breeds in the herd. The fat droplets in the milk from Ayrshires are intermediate between the Holstein and the Jersey. The Guernsey is comparable with the Jersey, while the Devon has very small globules. There is no relation between the size of globules and the richness of milk. These statements are based upon observations made at the Vermont Experiment Station and published in its twenty-fourth annual report.

Although the milk of Holstein cows has a smaller percentage of fat than that of Jerseys and Guernseys, the small size of the individual droplets is believed to have one advantage so far as infant feeding is concerned, for it is well known that fat must be emulsified before it can be digested, and a fine emulsion favors its digestion and assimilation. All Holstein cows do not furnish a milk poor in butter-fat. It is possible to obtain a milk from a Holstein herd (without any red cows) having the legal amount of fat — and more.

The first milk drawn from the udder is commonly poor in fat. This is known as "fore milk." The middle portion contains about the average percentage of fat, and the last, known as "strippings," is always richest in fat. The strippings may contain as much as nine or ten per cent of fat while the average milk contains but four per cent. The reason that the fore milk is poorer in fat than the strippings was formerly supposed to be due to the fact that the fat rises in the milk stored in the cisterns of the udder, but is probably accounted for by the fact that the fat sticks to the sides of the ducts. Hence the method of milking by manipulating the udder at the end of the flow secures an extra quantity of fat.

The cream layer is influenced by a number of factors. It may be destroyed by heat, agitation, and other agencies. As the cream line is one of the principal things that the householder looks for, the dairyman is very careful not to heat the milk too high in pasteurizing, and also guards against undue agitation, both of which tend to destroy this apparent evidence of richness. The richness of milk, however, cannot be judged by the depth of the cream line. There are several factors, — not the least of which is the narrow neck and thickness of the milk bottle, which gives an exaggerated notion of the amount of cream.

The cream does not always rise well in rich milk, even after standing more than twenty-four hours. The large fat droplets rise first and the very smallest may not rise at all. A watered milk throws up its fat more quickly than a normal specimen, although it does not contain as much. It appears therefore that a milk of inferior grade may show a deeper cream layer than a milk of unusual richness. Generally speaking, however, a rich milk will usually show its quality on standing.

The fat does not rise well upon heated milk. Milk may be heated to 145° F. for one hour without markedly influencing the cream line. If the milk is heated somewhat

higher than this, say 148° F., or for a longer time, the cream layer will blend with the milk below. If the milk is heated at still higher temperatures or for a very long time the cream scarcely rises at all.

It is very easy to destroy the cream line if milk is shaken or roughly handled: even if milk is poured from one can to another three or four times it tends to destroy the sharp cream line.

The emulsion of the fat in milk is peculiar in more than one particular. Ordinarily when a fat or an oil is mixed with water, the more it is shaken the finer and finer become the individual droplets and the more permanent is the emulsion. The opposite is the case with milk, for as soon as it is shaken, the fat droplets coalesce into butter. One reason for this is believed to be the fact that each fat droplet in milk is surrounded by an albuminous envelope. So long as this envelope is intact, the emulsion is secure, but as soon as it is broken by shaking, or softened and dissolved during the process of souring, the fat droplets readily run together and destroy the emulsion. For this reason it is much easier to make butter from cream that is "ripe," or partly fermented.

In normal milk the larger proportion of fat droplets group themselves together into tiny clusters or masses. This is known as the phenomenon of agglutination. At a temperature of 65° C. or above, these clusters are broken up and the globules are more homogeneously distributed throughout the liquid. This is one of the tests by which heated milk may be distinguished from raw milk.

When milk is subjected to a pressure of about three thousand pounds to the square inch and a temperature of about 75° C., the individual fat globules are broken up into exceedingly fine particles which remain as a uniform and permanent emulsion. This is known as "homogenized" milk. When this process is applied to cream it increases its viscosity, so that cream containing twenty per cent of

butter-fat when "homogenized" appears to have the body and richness of a thirty per cent cream.

The amount of fat in milk varies widely. In cow's milk the fat should not fall below three per cent, and except in unusually rich milk will not exceed five per cent. Good milk from a herd of well-fed cows should average not far from four per cent of butter-fat or about thirty-one per cent of the total solids of the milk. The variation in the amount of butter-fat is much more marked than any other constituent of the milk. The protein and milk sugar are usually constant.

The percentage of butter-fat in milk has long been one of the standards by which milk is tested. The richness, or the amount of fat in milk, is more of an economic than a sanitary question. Thus milk with only three per cent of butter-fat from Holstein cows is just as good a food as milk with five per cent of butter-fat from Jersey or Guernsey cows; the only difference being that there are more calories in the richer milk than in the weaker milk. Even skim milk containing little or no fat is a valuable food. The marketing of milk containing various amounts of butter-fat is therefore not so much a sanitary question as it is an economic question. It really belongs to one of the greatest reforms in the whole pure-food question, namely, "honest labeling." There is no reason why milk should not be labeled and sold as other foods, the price depending upon the grade and corresponding to its nutritive content. Some people might prefer Holstein milk, not because it may be sold a cent a quart cheaper, but because they prefer a milk less rich in butter-fat. This question will be discussed under milk standards.

Almost all the states and cities in our country have a law requiring milk to contain not less than 3.5 per cent of butter-fat. When the milk standard is relatively low, say 3.25 per cent, it is a temptation for dairymen to use inferior cows, cheaper feed, and, worse than all, it is a temptation

to remove the fat in excess of this low percentage. A mixed milk may contain 4.5 per cent of butter-fat. The law, we will say, requires only 3.25 per cent. The dairyman can therefore, with little chance of discovery, remove about 1 per cent of the butter-fat. This is all "velvet." Such practices should not be countenanced; they can best be guarded against by a careful system of inspection, supplemented by laboratory tests by which the partial skimming or "running" of milk may be detected.

The researches of Hübner, Keller, and Czerny show that the fats are more often the cause of much of the digestive disturbances in infants than the proteins. When the fat is excessive in amount the infant at first seems to thrive, but sooner or later loses weight and appetite and shows other symptoms of ill-health. At the same time the stools become a pale gray, hard and dry in consistency, and are composed largely of fatty soaps. The alkaline bases, which are deficient in cow's milk, are largely drawn from the body to saponify the excessive amount of fat in the intestines: a condition resembling acidosis may then appear. As a result of the deranged digestion, fermentation takes place in the intestines and the so-called catastrophe ensues. Many cases of summer complaint in children have been traced to an excessive amount of fat in the milk. There is a great temptation, both on the part of physicians and mothers, to increase the amount of butter-fat in the food in order to fatten their babies, but this practice is fraught with danger.

No discussion of fat in milk is complete without an acknowledgment to Professor S. M. Babcock, who, in 1890, discovered a ready method for estimating the amount of butter-fat in milk. This test, known as the "Babcock Test," is now used the world over. Babcock gave his knowledge free to the world. In 1901 the State Legislature of Wisconsin recognized his service by conferring upon him a bronze medal.

Milk-sugar. There is a special form of sugar in milk known as lactose. Lactose is peculiar to milk; that is, it is found nowhere else in nature. It does not exist in the blood or in any of the internal organs of the body. Sugar exists in the blood in the form of dextrose, and this must be transformed into lactose by the chemical activity of the secreting epithelial cells in the mammary gland.

Lactose, or milk sugar, belongs to the group of foods known as carbohydrates. These substances serve as fuel to yield force and energy in the form of heat and muscular power. They do not build up new tissue in the same way that the proteins or albuminous substances do.

When milk sugar is heated above the boiling-point of water, it changes to a brownish color; that is, the lactose is partially charred and a substance resembling caramel is formed. It is due to this fact that, when milk is boiled for a long time or heated to high temperatures, it turns a brownish color.

There is much less milk sugar in cow's milk than in human milk. Cow's milk contains on the average only about 4.5 per cent of lactose: woman's milk, about 7.0 per cent. This is why it is customary to add sugar to cow's milk used in infant feeding. The percentage of lactose is very constant in the milk of any particular species of animals at all times throughout lactation. It is therefore rarely necessary in clinical laboratories to make a special analysis to determine the amount of lactose. For public health purposes the percentage of lactose often furnishes a better guide to the adulteration of milk than the percentage of fat.

The milk sugar interests us particularly for the reason that it is readily acted upon by the bacteria which grow in milk. It is split up or fermented by these micro-organisms into lactic acid. The lactic acid thus formed causes the milk to turn sour and curdle, by throwing the casein out of solution.

The sugar of milk that is found in the drug store or when bought in commerce, is obtained from whey. It has a slightly sweet taste and is soluble in six parts of cold water. It varies very much in purity. When chemically pure, milk sugar occurs in hard rhombic crystals, but the milk sugar of commerce usually consists of indefinite masses.

Albuminous matter

Albuminous matter belongs to a class of chemical substances known as proteins. The proteins all contain nitrogen, and are therefore sometimes called nitrogenous substances. They are one of the essential, if not most important, classes of our food. The proteins build up new tissue and repair waste; they also serve to yield energy in the form of heat and muscular action. A typical example of a protein may be found in the white of egg or the lean of beef. Peas and beans contain proportionately a large amount of protein, while all vegetables, fruits, berries, and cereals contain a certain small proportion. Cow's milk contains about 4.5 per cent of protein substances while woman's milk contains only about 1.5 per cent. The difference is probably due to the fact that the calf matures much more quickly than the infant, and therefore needs more albuminous matter to build new tissue and repair waste. One of the reasons that cow's milk is usually diluted before being fed to infants is to avoid giving an excess of protein. The proteins are usually spoken of as being in solution in milk, but as a matter of fact they are in colloidal suspension; that is, they float as exceedingly small particles or molecular masses in the fluid.

Of the many different kinds of protein the following are the important ones in milk, namely, casein, lactalbumin, and lactglobulin. A trace of fibrin, mucin, and other proteins have also been found.

Casein is a highly specialized protein found only in the

secretion of the milk glands of all mammalian animals. It is insoluble in water, but forms soluble salts with alkalies. A solution of casein has a milky appearance. In milk, casein is found dissolved in the form of a neutral calcium salt which aids in giving to milk its white, opalescent appearance. The casein in milk exists in combination with calcium phosphate. It is not coagulated by heat, but is precipitated by acids, which combine with the calcium phosphate and throw the casein out of solution as a curd. This flaky or lumpy precipitate may again be dissolved in lime water and dilute alkalies. Casein is also thrown out of solution by rennin. The ferment in rennin throws out the casein from human milk and donkey milk as a flaky precipitate, but from cow's milk as a firm gelatinous mass. The difference in the character of the curds does not come from differences in the casein, but is due to the different salt content of the different kinds of milk. The casein appears to show no chemical difference in different kinds of milk. The percentage of casein, however, varies considerably. For example, the protein in cow's milk consists chiefly of casein, — 3.02 per cent, — while the protein in woman's milk contains only 1.03 per cent of casein.

It is important to have a clear understanding of the casein as well as the other proteins found in milk, for the reason that these substances are the ones which are the most obviously acted upon when milk spoils, when milk is heated, or when milk undergoes putrefaction.

Lactalbumin. The lactalbumin in milk is very similar to the serum albumin of the blood and corresponds to the albumin found in the white of an egg. Lactalbumin is coagulated by heat at 70° C., but not with dilute acids, while, on the other hand, casein is not coagulated by heat, but is readily precipitated from its solution by dilute acids. Lactalbumin contains sulphur, but not phosphorus; casein contains phosphorus. There is very little lactalbumin in

cow's milk (only 0.53 per cent): much more in woman's milk (1.26 per cent).

Lactglobulin is the third protein substance which occurs in milk. It is present in very small quantities; in fact, there may be mere traces.

While normal milk contains very little lactglobulin and small quantities of lactalbumin, colostrum is rich in these two substances, and therefore coagulates when it is heated. Lactglobulin coagulates at 75° C. and is precipitated in the same way as serum globulin, and like serum globulin is insoluble in water, but is soluble to some extent in weak salt solution.

In the system known as the "percentage method of infant feeding" special attention is given to the percentage of the albuminous substances in the milk formula. It is not only comparatively easy to make up formulæ containing definite amounts of protein, but the proportion of the various proteins may also be regulated. Thus it is easy to take out the casein from cow's milk by curdling it with rennin; or the lactalbumin and lactglobulin may be removed thus leaving the casein. In this way various combinations may be arrived at for the baby's good.

It is not usual to estimate the proteins in a sanitary analysis of milk, since different specimens of milk vary little in this regard, and since there is little inducement for sophistication so far as the proteins are concerned. If we know the weight of the total solids in milk and subtract therefrom the weight of the fat, ash, and sugar, the difference will represent the proteins. This method is sufficiently accurate for ordinary purposes. To estimate the nature of the various proteins requires special skill in organic analysis.

Inorganic salts

Milk contains certain definite proportions of inorganic salts, especially the salts of lime, potash, and sodium; also

small quantities of magnesia and traces of oxide of iron in combination with phosphoric acid, chlorine, and sulphuric acid.

The amount and nature of the inorganic salts vary considerably in the milks from different animals. Cow's milk contains almost four times as much inorganic salts as woman's milk. Thus cow's milk contains 0.75 per cent, while woman's milk only 0.2 per cent. When we examine the nature of these salts we find still greater differences, for the inorganic salts in woman's milk consist mainly of the alkaline bases, potassium and sodium, whereas the inorganic salts in cow's milk consist mainly of the alkaline earths, calcium and magnesium. This difference has an important bearing upon infant feeding. One of the reasons why cow's milk sometimes disagrees with babies, upsets their digestions, and results in ill-health is the fact that there is not enough potassium and sodium in the cow's milk which they receive.

Gases. Certain gases occur in their free state in milk. Freshly drawn milk contains a variable quantity of oxygen and always considerable carbonic acid and a slight quantity of nitrogen. Upon standing, the carbonic acid soon escapes and oxygen is absorbed. When milk decomposes, large quantities of carbon dioxide, as well as other gases, may be formed.

Enzymes or "life" in milk

It is commonly supposed that milk is not an inactive liquid, but possesses some indefinable principle or properties which are more or less characteristic of living tissues. Milk, indeed, possesses certain substances common to the blood and other vital liquids, such as antitoxines, opsonins, agglutinins, and other antibodies. Many of the cells in milk are doubtless not dead, and in other ways milk appears to possess "vital" properties. However, it is by no means proper to speak of milk as possessing "life," using

that term either as it is popularly or scientifically understood, for it possesses none of the fundamental properties of life. On the contrary, milk, like other dead organic substances, begins to deteriorate and decompose from the moment it is drawn, and sometimes even before it leaves the udder.

Milk is sometimes believed to contain life because it is rich in ferments or enzymes. These substances are exceedingly active. The chief enzymes found in milk are the catalases, peroxidases, and reductases. One of the principal ferments in milk is galactase discovered by Babcock and Russell. This ferment is capable of slowly dissolving protein substances. Ordinarily the galactase found in milk acts too slowly to cause any material change in the milk proteins in the short intervals which elapse between the withdrawal of the milk from the animal and its consumption as food. This ferment may assist digestion when milk is used in a mixed diet.

The peroxidases are interesting ferments in milk. They are substances capable of inducing the oxidation of guaiacum and other readily oxidizable substances by means of hydrogen peroxide. The reductases also interest us because they have the power of reducing certain chemicals. Thus they will change the color of methylene blue, an anilin dye.

The catalases, peroxidases, and reductases are used in the laboratory to determine whether a milk is fresh or old, and whether it has been heated or not. For example, a temperature of 70° C. for half an hour will kill almost all the ferments in milk. If a milk, therefore, does not give the reactions characteristic of the ferments, it is quite certain that it has been heated to a temperature above this point. In an old milk undergoing fermentation the activity of both the reductases and peroxidases is increased.

The thermal death-point of milk enzymes. The effect of

heat upon the activity of the ferments in milk is very similar to the effect of heat upon ferments or enzymes from other sources. Indeed, they are all very much alike and all of this great group of substances stand in such intimate and close relation to the vital activity of the cell that all those conditions which destroy the one, tend also to destroy the other.

In general, the ferments have a higher thermal death-point than the bacteria. The activity of most of the ferments begins to diminish at 60° C. and is seriously affected at 70° C., and at 80° C. they are destroyed. The non-sporebearing bacteria are destroyed at 60° C. It is therefore possible to destroy all the serious infections in milk so far as man is concerned without influencing its "life" so far as the ferments are concerned. In fact, it has been shown that milk heated to 60° C. increases the activity of some of the ferments, notably the peroxidases. All of the bacteria in milk cannot be destroyed without rendering the ferments inactive. This is because some of the bacterial spores must be heated to the boiling-point or over in order to kill them. It is fortunate that the harmful, non-sporebearing bacteria perish when exposed to heat before the ferments are seriously affected. It is fortunate because the ferments are the nearest approach to life we know of in milk and they probably exercise a favorable influence in digestion and nutrition.

The thermal death-point of the other vital principles in milk, such as antitoxins, opsonins, agglutinins, and other antibodies, are all approximately 60° C.; that is, they are destroyed at about the same temperature necessary to kill non-sporebearing bacteria.

Colostrum

The secretion of milk during the first few days after the birth of all mammalian animals varies markedly in composition and in amount from the milk secreted during any other

time of lactation. It is called "colostrum" or "beast milk." True milk is not present in the mammary glands until two or four days after parturition and occasionally not until the fifth day.

The amount of colostrum is very small. When it is obtained by slight suction it is light in color, watery, sometimes cloudy, with white or yellowish opaque streaks or threads. When larger quantities are pressed from the glands a slimy yellowish or even brownish to reddish liquid is obtained. Upon standing, the cream rises in colostrum as it does in normal milk, but the yellow color of colostrum adheres to the fat, and the cream layer of colostrum therefore has a more decided color than normal milk.

Colostrum corpuscles. Under the microscope a very large number of cells are seen in colostrum. These for the most part consist of the so-called "leucocytes"; rather, desquamated epithelial cells which are found in normal milk. Scattered in among these cells are numerous large granular bodies known as colostrum corpuscles. They vary greatly in form and consist of cells which are filled with fat drops and contain two or three small elongated nuclei. It is believed that colostrum corpuscles consist for the most part of leucocytes which have left the blood capillaries and have pressed their way through the glands. These particular leucocytes are active phagocytes and soon become laden with fat droplets. Some of the colostrum corpuscles probably represent altered or degenerated glandular epithelium.

Colostrum is specifically heavier than milk: its specific gravity is 1040 to 1080 and it may be either acid or alkaline in reaction. It is not so sweet as milk, but is rich in salts and proteins. It contains little or no casein, but a high percentage of the coagulable albumins, namely, lactalbumin and lactglobulin, so that upon heating it coagulates into a solid mass. It contains about as much fat as true milk.

COMPOSITION OF COLOSTRUM

	Colostrum Per cent	Cow's Milk Per cent
Protein	5.71	3.50
Fat	2.04	3.40
Sugar	3.75	4.60
Salts	0.25	0.75
Water	88.25	87.75
	100.00	100.00

Function of colostrum. The exact rôle of colostrum is not as yet fully understood. It has been inferred from the nature of its composition, especially its proteins, that it furnishes to the newborn animal, during its adjustment to its novel surroundings, nourishment of a character similar to that it received from the placenta as a fœtus. It is also believed to have a purgative action and thus serves to clear the digestive tract of meconium. That it serves a purpose is proved by its being the first secretion, not only of the human breast, but of that of all mammalians.

Practically all dairy rules, as well as many ordinances, forbid the use of milk fifteen days before and seven days after parturition.

Milk of different animals

While we are accustomed only to cow's milk, the milk of other animals is preferred in other parts of the world. Thus in parts of Europe ass's milk is much used. In Italy and other countries goat's milk is preferred. The milk of mares, buffaloes, camels, and other animals all have their advocates.

Milk varies in composition and characteristics according to the species of animal it is to feed. Thus the milk of the seal and whale is high in fats, to furnish blubber to the pup as an insulation against the cold water. The milk of the cow is high in calcium salts, to furnish material for the rapid growth of the bones.

Goat's milk is pure white, without especial pronounced odor or taste. If, however, the milking is done in a stable in which billy-goats are kept, the milk absorbs the same characteristic, unpleasant odor. The chemical composition of goat's milk is similar to that of cow's milk. The fat content may be a little greater. The butter-fat is white.

There is considerable prejudice against the humble goat and against goat's milk in this country. The goat is sometimes called "the poor man's cow." When we examine the question fairly, we find that goat's milk is cheaper, although a fairly good goat will only yield about two quarts of milk daily. One of the great advantages to goat's milk is that goats are practically immune to tuberculosis, and thus this danger is at once eliminated. Further, it has been shown that the fat in goat's milk rather closely resembles the fat in human milk. It is possible for babies to take their nourishment directly from the udder of goats. It is customary in many parts of Switzerland and France to carefully wash the udder and teats of the goat and permit the child to suckle directly. Thus the advantage of obtaining fresh clean milk is very evident. Spargo[1] states that, all things considered, the neglect of the goat as a milch animal, especially as a provider of food for infants, is very much to be deplored. The animal seems to be altogether well fitted to be the wet-nurse of the human infant, much more so than the cow, and it is a great pity that ignorance concerning its habits and qualities should stand in the way of its more general employment. While goat's milk is not apt to contain the tubercle bacillus it is very apt to contain the virus[2] of malta fever, which will be discussed farther on.

Sheep's milk is whitish yellow, rather thick, and possesses a peculiar, somewhat unpleasant taste and odor. It differs from cow's milk and goat's milk in its high fat

[1] *The Common Sense of the Milk Question.*
[2] *Micrococcus melitensis.*

and casein content, averaging about 9 per cent of fat and about 6.3 per cent of casein.

Mare's milk is usually distinctly alkaline in reaction, but may be neutral. It is white or bluish in color and has a somewhat pronounced sweet taste, due to the fact that it has a comparatively high percentage of milk sugar, namely, 6.6 per cent. The proportions of fat and proteins in mare's milk is conspicuously small, only 1.09 per cent of fat and 1.89 per cent of protein.

Ass's milk is essentially the same as that of mare's, and has in common with the latter a low fat and protein content and a large quantity of milk sugar. The milk of the ass more nearly resembles human milk than does that of any other animal, and in portions of Europe, for the most part, milk of the ass is the principal substitute used for the nourishment of infants.

Sow's milk is thick, slimy, and alkaline in reaction. Its chemical composition is very variable, especially so in regard to the fat content, which varies from 1 to more than 12 per cent. The quantity of protein averages about 6 per cent, but may vary from 5.7 to 15.5 per cent. The milk sugar varies from 2 to 3.8 per cent.

Bitch's milk is also quite variable in its composition, and the milk of the cat has not received much study. The rabbit and reindeer give milk particularly rich in fat and especially concentrated, but poor in milk sugar. The elephant shows very great fat and sugar content and comparatively little protein.

Whale's milk differs greatly from that of land animals. It contains only from 41 to 48 per cent of water, and fat in the enormous proportion of 43 to 45 per cent. There is 7.5 to 11 per cent of protein, and only about 1.3 per cent of sugar. Dolphin's milk is also highly concentrated, containing only about 41 per cent of water.

Zebu's milk has almost exactly the same properties and composition as ordinary cow's milk.

Buffalo's milk possesses a slight, pleasing odor and taste, is richer in solids than cow's milk, since the quantity of fat amounts to about 8 per cent, the proteins to fully 4 per cent, and the lactose from 4.75 to 5.2 per cent.

AVERAGE COMPOSITION OF MILK OF VARIOUS KINDS

Kind of milk	Water	Total solids	Casein	Protein			Carbohydrates (milk sugar)	Mineral matters	Fuel value per pound
				Albumin	Total	Fat			
	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent	Calories
Woman	87.58	12.6	0.80	1.21	2.01	3.74	6.37	0.30	310
Cow	87.27	12.8	2.88	.51	3.39	3.68	4.94	.72	310
Goat	86.88	13.1	2.87	.89	3.76	4.07	4.64	.85	315
Sheep	83.57	16.4	4.17	.98	5.15	6.18	4.73	.96	410
Buffalo (Indian)	82.16	....	4.26	.46	....	7.51	4.77	.84	....
Zebu	86.13	....	....	....	3.03	4.80	5.34	.70	....
Camel	87.13	....	3.49	.38	....	2.87	5.39	.74	....
Llama	86.55	....	3.00	.90	....	3.15	5.60	.80	....
Reindeer	67.20	....	8.38	1.51	....	17.09	2.82	1.49	....
Mare	90.58	9.9	1.30	.75	....	1.14	5.87	.36	....
Ass	90.12	10.4	.79	1.06	....	1.37	6.19	.47	215

Summary of the differences between cow's milk and woman's milk

The following table shows the average composition of cow's milk and woman's milk and shows, at a glance, the differences in the amounts of the principal constituents: —

	Woman's Milk	Cow's Milk
Fat	4. per cent	3(to 4) per cent
Protein	1.5	4.5
Sugar	7.	4.5
Salts	.20	.75
Water	87.30	87.25
	100.00	100.00
Calories per kilo	710.50	700.00

The difference between cow's milk and woman's milk is greater than the table indicates. Cow's milk is more opaque than woman's milk, although the latter contains a greater

percentage of fat. This is due to the opacity of the casein which is present in greater proportion in cow's milk.

Both milks are amphoteric or slightly alkaline in reaction when freshly drawn, but cow's milk is practically always acid when used under ordinary circumstances.

Cow's milk contains about four times as much inorganic salts as woman's milk. The composition of these salts, furthermore, varies markedly. In cow's milk the alkaline earths, such as lime and magnesia, predominate, while in woman's milk the alkaline bases, such as potassium and sodium, predominate. These differences have an important bearing upon infant feeding.

The amounts of fat in the two milks do not differ markedly. There is a difference in the composition of the fat. Woman's milk contains much more cholesterin, a fatty body, than cow's milk.

The sugar in the two milks varies markedly in amount, but not in kind. The milk sugar in both cases is in complete solution.

One of the chief differences between cow's milk and woman's milk lies in the proteins. Cow's milk contains 4.5 per cent, while woman's milk contains only 1.5 per cent. The reason for this is that the ratio of the growth of the calf, compared to that of the infant, is about as 2 to 1. Further, the protein of cow's milk consists chiefly of casein and little lactalbumin, while the protein in woman's milk contains more lactalbumin and less casein. For this reason the curd which separates out from cow's milk consists of tougher and larger masses than the curd from woman's milk.

The antibodies and other protective substances also differ in the two milks.

Man has but a single stomach and this forms about twenty per cent of the digestive tract. The cow has four stomachs which form about seventy per cent of the digestive tract. The calf's stomach is well fitted to handle and

digest the tough, lumpy curds which form from cow's milk. Woman's milk curdles into a soft mass which is broken into numberless small particles. Evidently the stomach of the infant fed with cow's milk is overtaxed trying to break the tough curds into particles small enough for complete digestion. It is therefore evident that even if we could secure cow's milk, the chemical composition of which was exactly the same as that of human milk, it would still be far from a perfect substitute unless it behaved similarly in the digestive tract.

CHAPTER III

DIRTY MILK

THE opacity of milk covers a multitude of sins. Almost all the milk found on the market is more or less dirty. The dirt may actually be seen, in many instances, at the bottom of a bottle of milk. When the dirt cannot actually be seen with the naked eye, it may readily be detected by

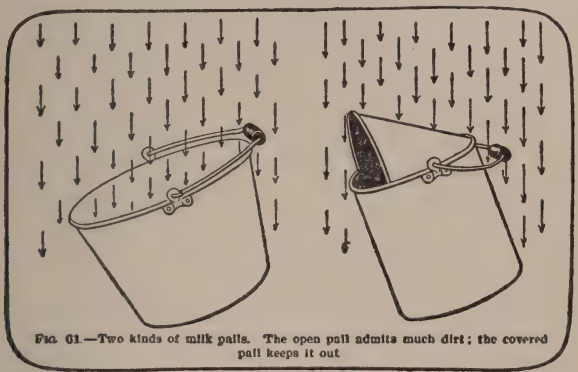


FIG. 61.—Two kinds of milk pails. The open pail admits much dirt; the covered pail keeps it out

TWO KINDS OF MILK PAILS. THE OPEN PAIL ADMITS MUCH DIRT, THE COVERED PAIL KEEPS IT OUT

straining a pint of milk through a little clean absorbent cotton, in which case a brownish or blackish stain will collect where the milk has been run through. This is a rough-and-ready test to determine the presence of dirt in milk. Many a farmer has opened his eyes when he has seen how much dirt may be strained out of a pint of milk which he produces.

Most of the dirt in milk is cow dung. It drops into the pail from the udder and flanks of the cow during the process of milking, especially if wide-topped pails are used or

if the cows are not clean or the methods are otherwise unsatisfactory. The dirt also comes from the dust in the air, from the hands of the milker, from the pails, and a thousand and one other sources.

Many a farmer when told that his milk is dirty is incredulous. When shown the dirt and told that it is cow dung, he is frankly astonished, for to the farmer cow manure is not dirt; in fact, it is the wealth of the farm. He has handled it, worked in it, spread it upon his fields, has seen it produce his richest harvest, and has found no harm come from contact with it. He cannot, therefore, understand why so much fuss should be made about a little cow manure in a bottle of milk.

As a matter of fact, all dirt may not be harmful. There is clean dirt and dirty dirt. But it takes a bacteriologist to distinguish between them. Even cow manure from a healthy animal may not be injurious, although it cannot be recommended as a nutritive food for infants. We shall soon see, however, that cow manure may contain tubercle bacilli which have been swallowed by the cow or may contain virulent streptococci and other harmful micro-organisms.

The most harmful kinds of dirt which get into milk are from human sources, as these are more apt to carry infection than any other. This kind of dirt is the more dangerous, as ordinarily it is invisible. Milk produced under unsanitary conditions is not necessarily dangerous, but is apt to be.

Bacteria cling to dirt. About one half the weight of cow manure consists of bacteria. Dirt in milk, therefore, is one of the chief sources of high bacterial counts. The bacteria favor decomposition and hasten souring. Dirty milk, therefore, spoils much quicker than clean milk; in fact, clean milk will keep two or three weeks without very much trouble, while dirty milk sours in a day or two. It is, therefore, not only for sanitary reasons, but from an economic standpoint that dirt should be kept out of milk.

Amount of dirt

It is a matter of surprise to many people to know that the laws of some places legalize a certain amount of dirt in milk. Thus in Dresden the standard regarding market milk states that it must not contain more than eight milligrams per litre.

The amount and nature of the dirt in market milk varies very greatly. An investigation in Hamburg showed that the quantity varied from none to 183.5 milligrams per litre, the average being 13.5 milligrams of dry dirt in a litre of milk. Schmelk, in Christiania, found an average of 11 milligrams in a litre; von Hellens found only 1.79 milligrams per litre in the milk of Helsingfors. In Berlin, Renk showed the average to be 10.3; in Halle, 14.92; in Leipzig, 3.8; and in Munich, 9.0. The maximum quantity in each case was much greater than the averages mentioned, although it never reached the maximum for Hamburg milk. The Copenhagen Health Commission had thirty-nine samples of milk tested for dirt, which was found in small quantities varying between one and thirteen milligrams per litre (Jensen).

Milligrams mean but little to the average mind, and even to the chemist they represent tiny amounts. If we transcribe these figures into ordinary language, we shall find a surprising interpretation. Thus, Commissioner Evans estimated that Chicago receives twenty-five tons of dirt in its city milk supply every year.

How ordinary dirt may be harmful

Ordinary dirt may not be especially injurious for the adult, but by unanimous consent it may be very serious for infants. No one doubts that milk containing millions of bacteria, even of the ordinary kinds, is not a fit food for the tender mucous membranes of babies. Like rotten fruit, such milk is known to be one of the causes of summer

complaints, and opens the door to many infections. In fact, the ordinary common bacteria found in dirt may, in themselves, be harmful for babies, especially in the summertime.

How can dirt hurt babies? Ordinary dirt may contain yeast. Now yeast is one of the beneficial microbes. It is the leaven which raises our bread and produces many fermented beverages and delicacies prized since great antiquity. It is scarcely possible to believe that ordinary yeast could hurt anyone. Nevertheless, when a baby takes dirty milk containing yeast, fermentation is apt to occur, the intestines become enormously distended with gas, paralysis of the bowels ensues, and death may result from this cause alone.

One of the humblest bacteria known is the hay bacillus, called *Bacillus subtilis*, in scientific parlance. This microbe is found almost everywhere, but especially in dirt. It very frequently gets into the milk. It is usually regarded as an entirely harmless and innocent citizen. But in unusual numbers the hay bacillus may cause serious havoc in the intestinal tract, especially of babies. It is capable of causing putrefaction, with the production of poisonous substances. When putrefaction occurs in the intestinal tract, "auto-intoxication" may take place. It has been shown that many a case of gastro-intestinal disturbance in children is associated with excessive numbers of the hay bacillus.

Another microbe ordinarily found in common dirt is the gas bacillus. Welch, who described this microbe, gave it the technical name of *B. ærogenes capsulatus*. This organism may cause fatal diarrhœa in babies, and is the cause of abnormal fermentation and a source of irritation and dysentery even in the intestinal tracts of adults.

We now know that some of the tubercle bacilli get into milk with the cow dung. Therefore, keeping out dirt will keep out a certain amount of this danger. Further, there

are streptococci and other bacteria in dung and dirt that may not particularly harm an adult, but may overwhelm the tender intestinal tract of the infant.

Then there are the toxic or poisonous substances which are said to form in dirty milk as the result of bacterial action. Although our information concerning the chemical composition of these substances is incomplete, this does not modify their harmful effects, if present.

Morse sums up the general verdict of physicians who make a specialty of the diseases of babies when he says that "without doubt the greatest injury is done by simply dirty milk in the warm season of the year; hence the high infant mortality in summer."

It is practically impossible to express mathematically the danger of dirt in milk. It may be that these dangers have been exaggerated. Dirty milk may not be poisonous, but it is apt to be. Scrupulous cleanliness must therefore be engraven upon the standard which should ever fly from the pinnacle of the dairy.

Taking out the dirt

All observing milkers have noticed that the foam which rises on milk gradually becomes darker as the milking proceeds, owing to foreign matter falling into it. A pail with a small opening and protected cover keeps out a large part of this dirty shower. Scrupulous cleanliness of the cow and surroundings and good dairy methods are necessary to eliminate the remaining portion.

Dairymen try to take out the dirt invariably found in ordinary milk by straining, filtering, or centrifuging. These processes take out the hair, straw, particles of fæces, some of the pus, blood, flies, and all sorts of gross things, but not the real dirt and not the real danger.

The milk to-day, therefore, appears to be cleaner than it used to be, but appearances in this case are frequently deceptive, for the milk perhaps is quite as "dirty," the

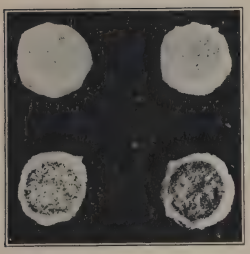
only difference being that the visible particles have been strained out.

It is now customary to take the dirt out of milk in one of three ways: —

(1) Straining through cotton, cheesecloth, or some similar material; (2) filtering through quartz gravel; (3) clarifying in a centrifugal machine.

Practically all the large dairies depend upon clarifiers to render their milk "clean." These clarifiers whirl the milk at great speed and throw out the dirt by centrifugal force. After several hours' run the dirt removed from one of these machines consists of brownish slime. The amount thus obtained is much greater than the amount obtained by any process of filtering or straining. This does not mean that clarifiers are more effective than straining or filtering. In fact, the purifying action of centrifugal clarifiers is deceptive, for these machines throw out some of the normal constituents of the milk which help to make up the dirty slime. The total amount of slime removed depends upon the rate of rotation and the time the milk is subjected to the centrifugal force.

All these so-called purifying processes render milk more acceptable to the sight, but do not improve the milk from a sanitary standpoint one jot or tittle. The visible dirt and gross particles are taken out, but not the bacteria or the infection. As a matter of fact, milk that has been strained, filtered, or clarified apparently contains a larger number of bacteria than it did before the "purifying" process. The reason for this is that the bacteria are enmeshed in the particles of dirt and are fond of grouping themselves together in clusters or colonies. When milk is strained, filtered, or centrifuged, the clusters are broken up. Further, the bacteria are washed out of the grosser particles into the milk. Hence, while the strained or clarified milk does not actually contain more bacteria, they are more generally and more evenly dis-



FOUR GRADES OF MILK AS INDICATED BY THE MILK SEDIMENT TEST. ONE PINT OF MILK WAS POURED THROUGH EACH OF THESE DISCS OF ABSORBENT COTTON WHICH WERE PERFECTLY WHITE AT FIRST. THEY SHOW FOUR GRADES OF MILK AS FOLLOWS: UPPER LEFT, *PERFECTLY CLEAN*, UPPER RIGHT, *SLIGHTLY DIRTY*, LOWER LEFT, *DIRTY*, LOWER RIGHT, *VERY DIRTY*

IT IS IMPOSSIBLE TO MAKE GOOD MILK WITH CHEAP LABOR AND CHEAP METHODS. IT IS IMPOSSIBLE TO MAKE BACTERIOLOGISTS OF SUCH MEN

Kindness of H. P. Hood & Sons.

ONE OF THE THINGS THAT MAY HAPPEN TO MILK DURING THE EARLY HOURS OF THE MORNING. INSIST UPON THE DRIVER RINGING THE DOORBELL; PLACE THE MILK BOTTLE IN THE REFRIGERATOR AT ONCE

tributed so that a larger number appear in each cubic centimetre.

The dairyman points with pride to his clarifier and tells how much it cost. The farmer is equally enthusiastic about his nickel-plated strainer which he purchased after seeing one at the dairy show. It would be more consistent if they apologized for these bright evidences of neglect.

The psychology of why people demand clean meat but not clean milk is a puzzle. Upton Sinclair's "Jungle" produced a profound effect, but Smollett's "Humphrey Clinker," a book written nearly one hundred and fifty years ago, containing a characteristic description and a scathing denunciation of the milk supply of Covent Garden, is still unnoticed. The conditions on the dairy farm are often worse than those at the slaughter-house and the dangers are much greater. These conditions have been pointed out with force and eloquence by many writers, but the facts do not seem to strike fire in the popular mind.

The dirt test

The dirt test is one of the most practical of the simple methods for controlling the milk supply. The Health Commissioner of Chicago in 1911 adopted the sediment test to reveal the presence of gross filth in milk. As an educational feature the results were better than was anticipated. The only way to convince the ordinary farmer that his milk is dirty is to show him the dirt. By the use of this test Chicago has refused the admission of many thousand gallons of milk from over five hundred different dairy farms.

The dirt test consists simply of filtering a pint or quart of milk through a little absorbent cotton. The brownish-black deposit upon the absorbent cotton tells the tale. In Chicago the Department of Health applies this test by means of a filtering apparatus. The cotton is placed in a porcelain crucible with a perforated bottom — a Gooch

crucible. This is attached to a filtering-flask which is connected with a vacuum pump. In this way a pint of milk may quickly be drawn through.

The Lorenz apparatus is made of copper with a jacket for circulating warm water, as it has been found that cold milk filters very slowly.

These dirt tests may be made "while you wait," and the dirt shown to the farmer; or they may be applied at the dairy where the milk is received, or in the city laboratory. A very good plan is to mail the little disks of cotton, containing the dirt, back to the farmer with a letter from the health officer.

The microscopic examination of milk

The following report gives a concise and satisfactory summary of the methods used for the microscopic examination of milk and the determination of the dirt in milk. This report was recently presented by Professor Conn to the Commission on Milk Standards of the New York Milk Committee: —

The microscopic examination of raw milk has been somewhat widely adopted, but apparently only in a few places has it been extensively used. In at least two laboratories where it has been tried, it has been given up as unreliable; but in general those who have used the method most are most enthusiastic as to its value.

There are two different methods of making a microscopic examination of milk: —

(*a*) The use of a centrifugal machine by the Stewart-Slack method. This method involves the centrifugalization of one or two cubic centimetres of milk and smearing of the sediment upon a slide, subsequently staining the same, and is so well known that it is unnecessary to describe it in detail here. It is the method that has been most commonly used. The results of this method vary considerably with details of individual manipulation, with the speed of the centrifugal machine, with the time allowed for centrifugalization, and with other individual factors. As a result, findings of one laboratory cannot be commonly compared

accurately with those of another, but they are fairly uniform when compared with each other.

(*b*) The direct examination of milk by the Prescott-Breed method. The details of this method are found in the "Cent. f. Bact.," 11, xxx, p. 337, 1911, but since it is somewhat new, a brief description of it will be here given. A capillary tube is prepared, arranged to receive a rubber bulb at one end and marked carefully to deliver one hundredth of a cubic centimetre. After a most thorough mixing of the milk, one hundredth of a cubic centimetre is removed with the sterilized pipette and spread uniformly over a square centimetre on an ordinary microscopic slide. It is allowed to dry and fixed with methyl alcohol, after which the fat is dissolved from it by the use of xylol. The smear is then stained either with methylene blue or preferably with one of the blood stains, the Jenner stain or Wright stain being useful for this purpose. If the staining is so deep as to make the specimen too opaque for proper study, it is slightly decolorized with alcohol, which removes the stain from the general sediment more readily than it does from the bacteria or the tissue cells. The stained smear is studied under a twelfth inch immersion. The draw tube of the immersion is adjusted so that the field of the microscope covers exactly fifteen millimetres and under these circumstances the number of bacteria present in the one hundredth of a cubic centimetre is exactly five thousand times the number found in a microscopic field. The counting of a large number of fields (one hundred fields) and averaging the results, multiplied by this number, will therefore give approximately the number of cells or bacteria contained in a one hundredth cubic centimetre of milk. This method has the advantage of eliminating all of the errors that are associated with the irregularity in the action of the centrifugal machine and many of the other individual errors connected with the Stewart-Slack method. On the other hand, it has the disadvantage of examining only a small quantity of milk, one hundredth of a cubic centimetre being hardly a fair sample. This disadvantage, however, may be met by making a very thorough mixture of the milk before sampling and by making the examination in duplicate. A second disadvantage is the large multiplier that has to be used to reduce the results to one cubic centimetre. This of

course very greatly increases any error that may appear in the observation, and introduces an error the extent of which cannot yet be stated accurately. It may in a measure be met by making the examination in duplicate and by averaging a large number of plate counts.

The chief advantages derived from the microscopic examination of milk are due to the quickness of the method.

(*a*) It makes possible the rapid discarding of poor samples of milk, since reports upon it are possible within a very short time.

(*b*) The quickness with which an examination can be made makes it possible for a single laboratory to examine many more samples of milk than by the older plate method, one person being able to examine and report upon fifty to one hundred samples in a half-day, and to make the reports upon the same day that the milk is collected.

The microscopic study of milk gives information upon the following points: —

(*a*) The abundance of cells which are present in the milk.

(*b*) The clumping of these cells, which is frequently noticeable in the centrifugal slime, but which is rarely if ever seen in milk that is examined by the direct method above mentioned.

(*c*) The bacterial count.

(*d*) The presence of chain-forming streptococci. (In this report when the term "streptococci" is used, reference is made to chain-forming organisms with at least six elements in a chain.)

(*e*) General information concerning the nature of the dirt and the source of the bacteria in the milk. With a little experience, one can distinguish certain types of bacteria which come from farm dirt from those that come from unclean vessels.

The estimation of the number of bacteria in milk by the microscopic study has the following advantages and disadvantages: —

(*a*) It is of no value when the number of bacteria in the milk is low.

(*b*) The microscopic examination gives numbers of bacteria vastly higher than those given by the plate method (in a series of twenty comparative tests, by one member of the committee, there was found an average of five thousand bacteria by the plate

method, seven hundred thousand bacteria by the Stewart-Slack method, and five million bacteria by the direct method of microscopic examination).

(*c*) In determining the total number of bacteria in milk, the microscopic examination is far more accurate than the plate method, since it gives practically all of the bacteria present, while the plate method gives only those that grow in special media under special conditions. The microscope, however, fails to distinguish between living and dead bacteria.

(*d*) The Stewart-Slack method of examining milk is of great practical use in those cities which have a bacterial standard of five hundred thousand, since it quickly detects milk which contains bacteria more than this limit, without the necessity of making a plate count. For samples that contain about five hundred thousand or less, it is necessary to make a plate count in order that the result may be reliable.

(*e*) Insufficient data are as yet at hand to determine the factor by which the milk could be condemned by the Prescott-Breed method. Data at present at hand would seem to indicate that nearly all samples of milk would approach or surpass this limit when the bacteria are determined by the direct method of examination of Prescott-Breed.

(*f*) No constant ratio can be found between the number of bacteria disclosed by the microscope and the number found by the plate count. There is a general parallel, but with many irregularities.

No method has yet been suggested for accurately distinguishing between the pus cells and other cells that may be in the milk that do not have an origin in inflammatory conditions. Some regard all noticeably clumped cells as indicating pus, stating that, upon proper incubation, all such clumpings may be found to be accompanied by chain-forming streptococci. Others regard all polymorpho-nuclear neutrophilic cells as pus. Most, however, at the present time fail to recognize any method of clearly distinguishing pus from tissue cells.

A general consensus of opinion has been reached that a high cell count should not alone condemn milk, although it is a matter for suspicion. The cell count varies with the same cow upon different days, and it may be increased by simply manipulating the

udders. Some believe that clumped cells always indicate an inflammatory condition.

A high cell count, accompanied by streptococci, apparently always indicates udder troubles. In many cases these have been followed up to the dairy, and where this has been done, it is almost always possible to find the source in some cow suffering from some trouble in its udders.

More data are needed before it can be definitely stated whether ill-health in children can be traced to milk that would be condemned by the microscope, although this has apparently been done in some cases.

At the present time it is impossible to give any standard for condemned milk by cell count, beyond the general rule that a high cell count, accompanied by streptococci, indicates an inflammatory condition or otherwise diseased udders.

Where the source of the milk is known, microscopic method of study is of great value in picking out animals with diseased udders. It is of especial help in directing attention to a herd that needs inspection and has been extensively and satisfactorily used in this way. In market milk, it is of great value where the source of the milk is known and can be reached, and its chief value is in finding the location of troubles rather than in condemning milk.

Concerning the value of the microscopic examination of milk, there are wide differences of opinion among those that have been using it. A few regard it as of little value and have discarded it entirely. Some have thought it of some value, but much less than the bacteriological plate count. Others regard it of more value than the plate count; and some have looked upon it as of so much value as to lead them to substitute it for the older method of bacteriological examination by plates, this latter method of examining having been quite abandoned. The claim is made in these cases that it gives better and quicker results and has been found of practical value in controlling the milk supply by pointing out the sources of trouble. All who have used this method recognize that it gives valuable data.

Concerning the Lorenz dirt test, the committee would make the following statement. Of the several methods of determining the presence of dirt in milk the committee believe that the most valuable is that of filtering it through a cotton disk. This com-

DIRTY FLANKS. A COMMON CONDITION IN WINTER. FLANKS BECOME CAKED WITH MANURE, WHICH THERE IS OFTEN NO THOUGHT OF REMOVING. THIS IS THE SOURCE OF MOST OF THE DIRT FOUND IN MILK

CLEANING COWS PREPARATORY TO MILKING. A SIMPLE OPERATION REQUIRING NO OTHER OUTLAY THAN A LITTLE TIME

mittee would suggest that a standard disk of an inch in diameter be selected for the filtering of a quart of milk, and a proportionate-sized disk for smaller amounts of milk. The Lorenz apparatus is simply a convenient filter for filtering milk through a cotton disk; but various other types than that distinctly known by this name are equally satisfactory. A Gooch crucible may be used conveniently, or any other device in which the cotton disk is supported upon a gauze and in such position that milk can be readily filtered through it. To be most efficient, the cotton disk should be subsequently dried and sent to the individual dairyman. In order to have the best results, the most desirable plan is to do the filtering in the dairy immediately after milking. For this purpose batteries of filters are needed, and these must be warmed in cold weather, in order that milk should pass through them readily. If these are used in the dairy, the results thus demonstrated to the dairyman are very convincing. The test is quick and simple and is proving very useful in locating unclean methods. It is much less cumbersome than the somewhat more expensive method of measuring the amount of dirt, and, although it does not give a quantitative but only comparative results, it is as useful for the purpose of detecting and remedying unclean conditions as the more slow and more expensive quantitative methods.

From these data the committee would present the following recommendations: —

1. The microscopical examination of raw milk, either by the centrifugal method or the direct examination of milk, gives very valuable information, since it presents in a few moments a graphic picture of the bacterial content as well as the number of cells, and offers a prompt method of excluding some samples of milk which are manifestly unfit for use, doing this promptly. To give the most valuable results, the committee would recommend the use of some good blood stain like the Jenner or the Wright stain.

2. Because of the irregularities in methods and results, no standard can yet be given for grading milk by the microscopic examination. Special attention is recommended to the presence of polymorpho-nuclear neutrophilic cells. A high cell count alone is not sufficient to condemn milk, but, if accompanied by chain-forming streptococci, it is an indication of udder troubles. The presence of streptococci alone is also sufficient to suggest the

same conclusion. The microscopic examination is, therefore, of great use in picking out animals with diseased udders, for the purpose of removing them from the dairy herd, after a proper examination of individual cows.

3. The data as yet accumulated are insufficient to determine whether the examination of milk by the centrifugal method of the Stewart-Slack type, or the direct examination by the Prescott-Breed method, gives the most reliable results.

4. The total numbers of bacteria found by the microscopic examination are so out of proportion to those given by those of the plate method that no ratio can be at present drawn between them.

5. Insufficient data have as yet been collected to determine whether the microscopic examination of pasteurized milk is of any value.

6. The determination of dirt by filtering a quart of milk through a cotton disk of an inch in diameter is advised as of the greatest value in detecting uncleanly conditions and in conveying a most graphic lesson of the need of cleanliness to the dairyman. Preferably this should be done in the dairy where feasible.

Bacteria in milk

Milk contains a vast number of bacteria. For instance, I found the general milk supply of Washington, D. C., averaged 11,270,000 bacteria per cubic centimetre in the summer of 1907, and 22,134,000 bacteria per cubic centimetre during the summer of 1906. The ordinary market milk of most other cities also is excessively rich in bacteria.

Such enormous numbers mean but little to our minds. If we make comparisons we find that few substances contain such myriads of germ life as is often found in milk. Compared with sewage, for instance, a liquid which is popularly and rightly supposed to teem with germ life, it will be observed that milk, when it is consumed, is often richer by far in bacteria than the sewage of our large cities. The number of bacteria found in sewage is shown in the following table: —

Sewage of	Average for	Bacteria per cubic centimetre
Boston, Massachusetts	1894–1901	2,800,000
London, England	1894–1901	2,000,000 to 11,000,000
London, England (crude sewage) .	1898	3,500,000 to 4,000,000
Lawrence, Massachusetts . . .	Sept. 24–Oct. 24, 1890	3,034,000
St. Mary's, Ohio	16 samples, 1907	5,600,000
Westerville, Ohio	16 samples, 1907	2,350,000
Marion, Ohio	16 samples, 1907	239,000

There are good bacteria and bad bacteria. Fortunately all the bacteria in milk are by no means harmful. Some of them may even be beneficial under certain circumstances. So far as mere numbers are concerned they need not greatly alarm us, for we know that disease is due to agencies and conditions other than merely the presence of enormous numbers of bacteria. By universal consent, however, milk containing excessive numbers of bacteria is not a suitable food. The tender mucous membrane of infants is very susceptible to bacteria and their products, and a certain proportion of the summer complaints of infants may be traced directly or indirectly to the use of bacteria-laden milk. As we grow older, it seems that the gastro-intestinal mucous membrane becomes comparatively immune or hardened, so that it is able to resist bacterial action which would be injurious or fatal to the tender infant.

If milk were a transparent liquid, the enormous growth of bacteria often found in market milk would be plainly visible to the naked eye. A similar amount of bacterial growth in broth, gelatine, beer, jelly, or other clear substance would render such food unsightly, and it would generally be regarded as unfit for use on account of the evidence of bacterial growth, if not on account of the evidence of actual fermentative and putrefactive changes.

The number of bacteria in milk is not so important from

a public health standpoint as the kind of bacteria and the nature of the bacterial products. With cleanliness and a liberal use of ice, the large number of bacteria can be kept down and this affords a certain amount of protection against the dangerous varieties and the development of their toxic products. Milk containing few bacteria is apt to contain proportionately few or no harmful varieties. The fact, however, is not to be ignored that a number of serious milk-borne outbreaks have resulted from infection in a "clean" milk containing comparatively few bacteria of the ordinary kind.

Most of the harmful bacteria which cause disease in man grow best at the body temperature and not at all at the low temperatures at which milk must be kept in order to keep the total bacterial count down.

Where the bacteria come from. The bacteria in milk come from many different sources. Some of them are already in the milk before it is drawn from the udder. Others get into the milk from the dust in the air or fall into the milk pail with the dirt from the cow. Still others are introduced into the milk from the hands of the milker. A certain number get into the milk from the milk pails, milk cans, and other objects with which the milk comes in contact. When a fly falls into milk it carries with it undesirable parasites and possibly infection. The bacterial population of a fly is from 550 to 155,000,000.

Every time milk is handled there is an increase in its bacterial content. Unless painstaking precautions are observed, milk receives fresh bacterial contamination every time it is poured from one vessel to another, every time it is stirred, tasted, uncovered, or handled in any way. Separator milk may contain more bacteria than the original milk and the same is true of filtered milk. Thus, milk strained through gauze or cotton, or filtered through gravel or any other device, while it looks cleaner, almost always contains more bacteria than before it was "purified."

This is due largely to the fact that while the visible particles are held back, the lumps of manure, dirt, and bacterial clusters are broken up. Therefore, when the bacteria are counted we obtain a thousand or more colonies where only one developed before.

The initial contamination of milk. For the most part, bacteria do not pass a healthy udder. However, we can place no trust in the filtering ability of the mammary gland. It is known that the virus of foot-and-mouth disease, which is so tiny as to be ultramicroscopic, and the virus of milk sickness, and the micrococcus causing malta fever are found in the milk of affected animals; that is, the milk of such animals contains the virus even though the udder may not be diseased. There is good evidence that the tubercle bacillus does not appear in the milk as it leaves the teat, unless there is tuberculosis of the udder, and the same is true of most of the pathogenic micro-organisms, with the exceptions above noted.

We know that milk freshly drawn from the udder under ordinary circumstances practically always contains some bacteria. Thus I have found that milk obtained by careful methods from separate cows had from 60 to 8300 bacteria per cubic centimetre. These numbers evidently do not represent the real number of bacteria present, for the reason that not all the bacteria produce visible colonies upon agar plates, and further, each colony does not necessarily represent the growth from one micro-organism. The bacteria in fresh milk are very apt to agglutinate into clusters. This milk which contained from 60 to 8300 bacteria per cubic centimetre was obtained by first washing and disinfecting both the udder and the hands of the milker as though preparing for a surgical operation. A sheet wet with bichloride of mercury was then placed around the cow, leaving only the teats projecting through appropriate openings. The fore milk was discarded and the samples to be examined were drawn immediately into sterile test tubes. De-

spite these precautions the milk contained a surprisingly large number of bacteria. Sedgwick and Batchelder in 1892 found that, with moderate precautions on the part of the milker, the number of bacteria in fresh milk may not exceed 500 to 1000 per cubic centimetre. Similar results were obtained by a number of other investigators. Von Freudenreisch, in 1902, thought that it would be easy to carry out strict asepsis and thus obtain bacteria-free milk, but he soon came to the conclusion that this was impossible. He found the bacterial content of the mixed milk of twenty-eight cows, obtained with exacting precautions, varied from 65 to 680 micro-organisms per cubic centimetre.

From the examples quoted we see that it is practically impossible to obtain bacteria-free milk in large quantities, but it is comforting to know that the organisms in carefully collected milk from a healthy animal are not ordinarily harmful.

Where do these bacteria come from? Our common sense tells us that the mammary glands do not secrete bacteria; they secrete milk. We would expect to find milk freshly drawn from the udder with careful aseptic precautions to be germ free. It is, therefore, a surprise to know that milk is usually contaminated before it comes into the outer world. It is plain that the bacteria may squirm or grow up the milk duct of the teat into the milk cistern. Once having reached the milk cistern they there find perfect conditions for rapid development; a nice, warm, cozy, dark home with an abundance of food — all the conditions necessary for germ development. In truth, the bacteria multiply in the milk cistern and that is why the fore milk, or the first milk which is obtained from the cow, is always much richer in bacteria than the mid-milk or the strippings. In good dairy practice the fore milk is always discarded.

Sometimes the bacteria invade the deeper portions of the gland and may even be found in the alveoli.

Recently Mr. S. L. Stewart, of Brookside Farms, Newburgh, New York, has surprised the bacteriological world by producing milk in rather large quantities almost free of bacteria. When planted by the usual methods upon agar plates this milk gives no bacterial growth in small quantities such as one hundredth of a cubic centimetre. Such remarkable results are noteworthy.

Mr. Stewart makes the following statement as to how these results were obtained: —

The cows are fastened up so that they cannot lie down until after being milked. They are then cleaned with brush and curry-comb and all soiled spots are scrubbed with a brush, using a five per cent solution of disinfectant in the water, after which the body of the cow is dampened from the neck back. The tails are dipped in water containing a washing compound and a disinfectant, care being taken to dampen the tails from the root down. The udders are then washed with a washing compound, then disinfected with a one per cent solution of cresylone, a refined product, with a very slight odor, containing great germicidal properties. After this has remained on about ten minutes, the udders are rewashed with sterile water. This water is drawn from a boiler in which it was sterilized. The water pails are kept for this purpose alone and previously sterilized. The udders are then dried, using a sterile towel for each cow. The heads of the cows are then sprayed with a fine spray from a nozzle, using tepid water, after which the walls and ceilings are sprayed with a fine spray from the same nozzle, thus laying any dust that may have collected and taking care of all bacteria in the air or on the wall surface. The interior of the barn is a smooth surface, produced by several coats of paint, finished with ripolin enamel, making a very hard surface. After this the men wash their hands, faces, dampen their hair, and put on clean sterilized suits and a cap. Between milking they re-wash their hands, using sterile water drawn from a hospital lavatory operated with a foot-lever. The milk from each cow is handled separately, being strained through a separate cheese-cloth strainer for each cow, the strainer being examined by the dairyman to guard against any udder trouble which can be detected on a strainer cloth before it could be detected by feeling

of the udder or by the act of milking, thus eliminating the danger of pus cells in the milk.

The significance of the number of bacteria in milk. Of all the routine laboratory tests, the simple enumeration of the number of bacteria in milk tells us most concerning its general sanitary quality. A large number of bacteria in milk means that it is old, that it has not been kept cold, or that it is dirty. The number of bacteria in milk will depend upon any one of these three conditions: time, warmth, or dirt. When the milk is old, warm, *and* dirty, the numbers will be prodigious. Any combination of these three factors, or any one of the factors operating alone, will result in an excessive number of bacteria.

The number of bacteria in milk cannot be taken as the only index of its sanitary quality, although, generally speaking, a milk that is rich in bacteria is undesirable for human consumption and may be dangerous to infants and children. The differences in sanitary importance of the high and low bacterial counts are not proportionate to the numerical differences. Under certain circumstances bacteria are purposely permitted to grow in milk until their numbers are inconceivably great — over a billion per cubic centimetre. This is the case with buttermilk and the various sour-milk products which have recently become so popular owing to the teachings of Metchnikoff that such a diet prolongs life. This question will be discussed later. It is plain, however, that large numbers of bacteria in themselves may not be an infallible index of the sanitary quality of the milk, for children stand buttermilk very well, in fact, some physicians use buttermilk to correct dietetic errors and summer complaints of babies. Buttermilk, however, contains practically a pure culture of bacteria known to be harmless and purposely allowed to grow and multiply in the milk and must not be confused with the miscellaneous bacterial population ordinarily found

in stale, warm, and dirty milk frequently found upon the market.

While the number of bacteria are not so dangerous as the kind, there is, however, no safety in numbers. We have to judge the good bacteria by the company they keep, and therefore must look askance upon bacteria-laden milk. The number of the bacteria in milk at once gives a clue as to (1) the cleanliness of the methods employed, (2) the temperature at which the milk has been held, and (3) the age of the milk. Bacterial counts, then, are of great practical use to the health officer. In fact, bacterial counts have become indispensable in order to control and regulate the milk supply. With bacterial counts as a guide it is comparatively easy to determine the cause of trouble or to locate just where the trouble takes place. With a proper diagnosis it becomes easy to institute proper treatment and to prevent its recurrence.

The enumeration of bacteria in milk is, therefore, the readiest and cheapest method at our disposal to determine the general sanitary quality and grade of the milk. The laboratory results serve as a guide to direct the efforts of the inspector, and they also may be used to confirm the conclusions arrived at from an inspection of the dairies and dairy farms.

It should be borne in mind that while the bacteriological examination of milk has its uses, it also has distinct limitations. Some of these have already been noted. From a practical standpoint the long time required to obtain results is its greatest drawback. Professor Theobald Smith states: —

> One of the serious limitations to the present bacteriological examination of milk as practiced by boards of health, even where the most elaborate laboratory tests are carried out, fail to trace the evils to their sources, since only mixed milk is examined. It may be compared to hunting in the Mississippi River delta for what has been poured into the river at Minneapolis. It would be

better to send an inspector up the river and use the routine bacteriological tests as a check upon his work.

Fortunately bacterial counts are comparatively easy to make, so that an unskilled assistant may soon be taught to count the number of bacteria in milk sufficiently accurately for practical purposes.

Progressive dairymen find it a distinct advantage to make bacterial counts of their milk in order to improve the supply. Such counts are of invaluable assistance in controlling methods, in discovering just which cow, what person, or what part of the industry is at fault.

One of the special advantages accruing from the bacteriological control at the dairy is that it affords an opportunity to exclude the milk of diseased cows. Cows suffering with inflammation of the udder known as garget, or mammitis, which is the most common of all bovine diseases, usually yield a milk rich in bacteria. The milk from an inflamed udder not only contains many bacteria, but contains large numbers of the pus-producing organisms, especially streptococci. These streptococci are sometimes particularly virulent and good dairy methods require every precaution to keep them out of the milk. Such milk may be particularly dangerous when fed to infants.

Finally, bacterial counts are indispensable checks upon the efficiency of pasteurization.

The number of bacteria in milk is always stated in round numbers. These numbers represent minimal rather than maximal counts; that is, the number of bacteria as given by the bacteriologist is always less than the actual number of bacteria present in the milk. There is no known method by which the entire bacterial population in milk may be counted, because some of them do not grow upon our ordinary culture media; furthermore, a colony is taken to represent a single germ, whereas it may have developed from a cluster.

The number of bacteria in milk, then, is an index of

the cleanliness of its production, its age, and temperature.

Legal standards. The first attempt to make a standard for the bacteriological content of milk was undertaken by the New York City Board of Health which, in 1900, believed it was not necessary for any milk sold in New York to contain over 1,000,000 bacteria per cubic centimetre. It was found, however, practically impossible to enforce such a standard for the city of New York on account of the complexity and enormous volume of the milk trade of that city. The principal difficulty was to place the responsibility when the milk was found to contain an excessive number of bacteria, for the product passes through so many hands before it is delivered to the consumer. In such a case it, therefore, becomes necessary to trace the milk from the consumer to the farm, taking bacterial counts at several points along the route.

Boston, on the other hand, made a strict standard of 500,000 bacteria per cubic centimetre, which was legalized by the Board of Health June 6, 1905, in article VI, section 1, of the "Regulations for the Sale and Care of Milk." According to Jordan the adoption of a bacteriological standard by the Boston Board of Health was at first decried and the subject of scoffing, but the example of that city has since been followed by other municipalities, until now over twenty cities are conducting bacteriological investigations of their milk supplies. This outcome is fortunate, for from multiplication of work of this character great progress may be expected.

Goler, the efficient health officer of the city of Rochester, in 1907 issued a circular to all milk producers supplying that city informing them that thereafter 100,000 bacteria per cubic centimetre would be made a maximum standard.

Bitter believes that no milk should be sold in cities, if it contains more than 50,000 bacteria per cubic centimetre.

Park states that any intelligent farmer can use sufficient

cleanliness and apply sufficient cold, with almost no increase in expense, to supply milk twenty-four to thirty-six hours old which will not contain, on the average, over 50,000 bacteria per cubic centimetre in winter and 100,000 in summer; and that milk containing more bacteria than this should not be used.

The above figures apply to standards that have been recommended for market milk. The high figures are not high standards. A limit of 500,000 bacteria per cubic centimetre is rather a low standard and an admission that better milk can hardly be obtained under present conditions. In time these figures will doubtless be reduced. So far as milk for infant feeding and other clinical purposes is concerned, the standard established by Coit of 10,000 bacteria per cubic centimetre as a maximum for certified milk seems, by unanimous consent, to be the best. Some communities have adopted a second grade of milk, known as "inspected milk from tuberculin-tested cattle," obtained under cleanly conditions and not containing over 100,000 bacteria per cubic centimetre.

The number of bacteria, therefore, allowable in milk depends upon its grade and the purposes for which it is used and varies somewhat with the locality. It is evidently much easier to obtain milk containing fewer bacteria in small communities with a near-by supply and in cold climates than it is in large cities with inevitable delays in transportation or in Southern latitudes.

As a general rule, then, it may be said that certified milk should never exceed 10,000 bacteria per cubic centimetre; inspected milk, not over 100,000; and health officers should aim to keep the general milk supply below the 100,000 mark.

The kinds of bacteria in milk. We still lack satisfactory routine methods to determine the kinds of bacteria which populate milk. The real harmful varieties, such as the typhoid bacillus, the diphtheria bacillus, the tubercle

bacillus, the streptococci, etc., do not grow well upon the ordinary media used for counting the number of bacteria in milk. It requires special methods to determine whether milk contains these specific micro-organisms.

The number of fermenting organisms in a sample of milk may be estimated by planting progressively smaller quantities in fermentation tubes containing glucose or other fermentable sugars. A very good test is known as the "Wisconsin curd test." This consists in coagulating the milk with rennet and allowing the curd to stand in a warm place for several hours. If gas-producing organisms are present, the curd when opened will be found to be full of gas bubbles like Swiss cheese. The presence of many gas-producing organisms usually indicates dirty conditions of stables, cows, or containers. A few gas-producing organisms may be found in most milks.

By sowing the milk upon gelatine plates the relative number of liquefying bacteria may be determined.

By the use of Endos media or lactose litmus agar the number of acid-producing bacteria may be determined. Other special groups may be differentiated by special technic.

It takes six weeks to determine whether tubercle bacilli are in milk; from three days to a week to determine whether it contains typhoid bacilli; two to three days or more to determine whether the streptococci are virulent; and several days to a week to recognize diphtheria bacilli in milk. These examinations, therefore, are not practical as routine tests, for the milk would be consumed long before the knowledge was available.

The streptococci in milk deserve a special word. There are very many different kinds of streptococci. A few streptococci will be found in the sediments from most milks. They are seldom found to any great extent by direct microscopic examination of a clean product. Occasionally a

sample will be found crowded with long chains. Often streptococci, if present, are in the form of diplococci, or very short chains. The common interpretation is to regard the short-chained varieties and the very large streptococci as probably harmless, while the long chains (six elements or more) are looked upon with suspicion, and may be taken as an evidence of inflammatory conditions of the udder. A milk containing a large number of streptococci is certainly not a safe article of diet.

Unfortunately the most virulent streptococci, that is, the ones that are most to be dreaded, are the very forms that grow poorest upon our artificial culture media. Thus the routine examination of the Deerfoot Farm milk, during the epidemic of sore throat which occurred in Boston in 1911, failed to discover streptococci. The disease produced, however, was a streptococcal infection.

Leucocytes in milk

A large number of cells are normally present in cow's milk and probably in the milk of all other animals. These are not to be regarded as the result of inflammation unless true leucocytes or pus cells are excessive or accompanied by streptococci. The cells in normal milk are, for the most part, probably degenerated epithelial cells, although they are commonly called leucocytes.

The cells present in milk,[1] the so-called leucocytes, are very diverse in nature, and when critically examined the majority distinctly differ from leucocytes. The cells ordinarily present in normal milk, however fresh, practically never exhibit amœboid motion. The ingestion of bacteria by the cells in milk is practically absent.

The number of cells in milk is greatly increased in the presence of garget, toward the end of lactation, on approaching calving-time, during periods of excitement, or they may be increased on account of various other factors.

[1] For a discussion of the cells in milk see pages 28–30.

Heated milk appears to have more cells than the raw milk for reasons that are not at all clear.

The cells in the milk are not in themselves harmful. They may indicate inflammation either through their character, their excess of numbers, or association with harmful micro-organisms, especially the streptococci.

The germicidal property of milk

The so-called germicidal property of milk has been much misunderstood. Judged by the number of colonies that develop upon agar plates the bacteria at first diminish, then increase in number. This apparent diminution occurs only in raw milk during the first eight or twelve hours after it is drawn. Although the bacteria seemingly decrease in numbers, they never entirely disappear. After the initial decrease there is a continuous and rapid increase until the milk contains almost infinite numbers in each cubic centimetre.

This power of milk to restrain the development of bacteria lasts from six to twenty-four hours, depending upon the temperature at which the milk is kept. If the milk is kept warm, say at body heat, the decrease is pronounced within eight or ten hours. After this the milk entirely loses its restraining action. If, on the other hand, the milk is kept cold, say at 15° C., the decrease in the number of bacteria is less marked, but the action is more prolonged, sometimes lasting twenty-four hours.

No actual decrease in the number of bacteria really takes place. The decrease is apparent rather than real, and is due in large part to the fact that the bacteria in the fresh milk agglutinate into clusters. Each group then grows as one colony upon agar plates. This may be proven by the fact that these clusters may be shaken asunder and separate colonies obtained from each individual organism. The germicidal action is, therefore, not a true power to destroy bacteria at all, but there is a definite though tempor-

ary power of fresh milk to restrain and retard the growth of bacteria. The fact that the germicidal action of milk must be very feeble may be guessed *a priori* from the fact that bacteria grow in the perfectly fresh milk in the milk cistern and ducts of the mammary gland.

The restraining action is specific, at most is very feeble, and is destroyed if milk is heated above 80° C. The germicidal action varies in different animals and in the milk from the same animal at different times. It cannot take the place of cleanliness and ice, but may be taken advantage of in good dairy methods.

The power of fresh milk to restrain the growth of bacteria corresponds to a similar power possessed by the blood and other important fluids in the body. The germicidal action of milk is one of the chief reasons why fresh milk is so much better than milk twenty-four hours or more old.

Pasteurization is sometimes objected to for the reason that the heat destroys this germicidal power and for the further reason that the bacteria grow better in heated milk than in raw milk. As a matter of fact, the temperature at which milk should be pasteurized has very little influence upon the germicidal activity. Further, this power has long ceased to operate when the average market milk reaches the city. Bacteria grow quite as quickly in raw milk twenty-four hours old as in heated milk.

Why milk spoils and how

Milk left alone ordinarily turns sour and curdles. This occurs in the great majority of instances and is therefore called the normal method. It is not "normal" in any sense except that it is the usual form of fermentation which takes place when milk is left to itself. When we examine into this subject a little more closely we find that milk will spoil in a great variety of ways. The cause of the changes which take place in milk is always due to the action of micro-organisms, but the kind of deterioration depends upon the

MOSQUITOES, FLIES, RATS, AND OTHER VERMIN BREED UNDER SUCH CONDITIONS; THEY ENDANGER THE HEALTH OF THE FARMER AND MAY CONTAMINATE THE MILK

SHOWS A CLEAN BARNYARD AND WELL-LIGHTED BARN

kind of bacteria, moulds, or yeasts which happen to be present and take part in the process.

Milk either putrefies or ferments. Putrefaction and fermentation are two general terms which include a great variety of changes which take place when milk or any other organic substance undergoes decomposition. By putrefaction we understand more particularly the breaking-down of nitrogenous substances, while fermentation deals more particularly with the breaking-down of the sugars and starches. The two processes are not only exceedingly unlike, but have a very different health significance. Putrefaction and fermentation do not, as a rule, take place in the same substance at the same time. In a mixture containing both albuminous substances and carbohydrate substances, fermentation takes precedence; that is, the carbohydrates will ferment before the albumins putrefy. In this sense the carbohydrates protect the proteins. Hence milk, which contains both albumins and carbohydrates, almost always ferments and rarely putrefies.

Some of the products of putrefaction are poisonous. They are popularly called ptomaines. As a matter of fact, ptomaines themselves are not really very poisonous, but toxic substances whose composition is not clearly understood are believed sometimes to be produced during the putrefactive process. It is interesting to note that it is almost always the intermediate products of putrefaction that are dangerous, while the end products of putrefaction, such as carbon dioxide, nitrates, etc., have no sanitary significance in this connection. On the other hand, it is the end products of fermentation, such as acids and alcohol, which are poisonous in sufficient concentration whereas the intermediate products of fermentation have little or no poisonous action.

Putrid milk need not be decidedly foul. In fact, the early stages of putrefaction, when the milk is only bitter due to the formation of peptones, may cause nausea and vomiting

even in adults. Many instances have been recorded in which it is asserted that such milk has caused the poisoning of large numbers of people. In such cases it is doubtful whether the trouble is due to a chemical poison formed in the milk, for in the case of meat poisoning, or so-called ptomaine poisoning, we know the symptoms are really the result of a bacterial infection, and are not the result of toxines or ptomaines.

The ordinary souring of milk is, therefore, a conservative process, and is sometimes known as nature's danger signal. It is really not a danger signal at all, for sour milk, buttermilk, koumiss, and other forms of fermented milk are a very good and nutritious food, sometimes even for delicate babies. Fermentation, far from being a danger signal in milk, is rather a flag of truce or safety device which prevents or retards the development of poisonous properties.

Fermented milk is acid in reaction, has a sour smell, shows the well-known curd, which consists of precipitated casein, and is not particularly harmful. On the other hand, putrid milk is more alkaline in reaction, has a disagreeable, even disgusting odor and taste. The curd is gelatinous and undergoes self-digestion, while the products of the putrefactive process may be harmful.

The particular micro-organisms which produce fermentation are known as lactic acid organisms. There are many different varieties. The principal ones are the *Bacillus acidi lactici* of Hueppe, the *Bacillus lactis acidi* of Leichmann, the *Streptococcus lacticus* of Kruse, and, in addition to this, sometimes other organisms, such as the *Bacillus ærogenes*, the common colon bacillus, the *Bacillus bulgaricus* of Metchnikoff, various streptococci, etc. The cause of the souring is the conversion of the milk sugar into lactic acid due to the bacterial action. The bacteria which cause the normal souring of milk for the most part get into the milk with the dirt. Milk that is obtained with scrupulous care will not contain the lactic acid organisms in

sufficient number to cause souring. Such milk may, therefore, putrefy with age. Thus we have actually found that the best samples of certified milk which have been examined in my laboratory did not contain nature's danger signal, and when kept a long time did not sour normally, but underwent the less desirable form of decomposition.

The use of sour milk has recently come into vogue through the teachings of Metchnikoff, who called attention to the importance of the normal acid-producing flora in the large intestines and recommended the use of certain bacteria in sour milk, especially the *Bacillus bulgaricus*. It is a fallacy to suppose that the flora of the large intestines may be materially influenced by the ingestion of these bacteria, even though they are taken in enormous numbers such as the countless myriads present in sour milk. For example, a sour milk may contain several billion bacteria in each cubic centimetre. The number in a glassful would scarcely be equaled by the stars in the heavens. The best way to change the intestinal flora is through diet. With a carbohydrate diet these acid-producing organisms gain the ascendancy and keep back protein putrefaction and in that way tend to prevent what is known as auto-intoxication.

Colored milk

Blue milk is usually caused by the *Bacillus cyanogenes*. Such milk is apparently harmless. Red milk may be due to the presence of blood. The blood comes either from an injury to the udder or some acute inflammatory disease. A reddish color in milk may also result from the feeding of the cows on plants containing red pigment, such as the madder root. A red color will also be produced by the *Bacillus erythrogenus*, the *Bacillus prodigiosus*, or certain sarcinæ. The production of red milk through the agency of bacteria is without sanitary significance.

Slimy or ropy milk

Under certain circumstances mucilaginous substances develop in milk through abnormal fermentations. Slimy milk has been obtained of such viscosity that it could be drawn into threads ten feet in length and of such thinness as to be scarcely visible. In Norway such milk is esteemed a delicacy. In this country, however, it is objectionable. Such milk appears to have no injurious properties unless the milk is slimy as the result of muco-purulent secretions caused by diseased conditions in the mammary glands.

The bacteria which produce slimy or ropy milk are widely distributed in nature. The *Bacillus lactis viscosis* of Adametz is the commonest of these found in Europe. A similar organism occurs in this country. It is a very hardy microbe and finds its way into milk through the water supply and other sources. When dairies become infected with this organism it may become very troublesome and can only be eradicated by thorough cleanliness and great care. Sometimes it is necessary to resort to disinfection. The other organisms producing sliminess in milk are the *Micrococcus freudenreichii*, two forms of streptococci, and certain of the lactic acid bacteria.

Bitter milk

Freshly drawn milk sometimes has a bitter taste. In other instances milk acquires such a taste on standing a few hours. The former is due to improperly feeding the cows with such herbs as lupine, wormwood, turnips, cabbages, etc. When the bitter taste develops in milk some hours old, it is due to the growth of certain bacteria in the milk after it is drawn. The condition is very undesirable and sometimes causes much trouble for the dairyman, but is not known to be a cause of illness. According to Conn, it is a micrococcus, and according to Weigmann, it is a

bacillus that has the power of ruining the taste of freshly drawn milk in a few hours.

When milk putrefies it is also known as the alkaline fermentation of milk. Such milk has a bitter taste and a soft, slimy curd. The principal causes of putrefaction in milk is the ascendancy of the sporebearing groups of bacilli belonging to and resembling the common hay bacillus.[1]

Alcoholic fermentation of milk

This is an abnormal fermentation which sometimes occurs as a result of certain yeasts aided in their action by certain species of bacteria. Alcoholic fermentation of milk never occurs spontaneously, but may be induced by direct inoculations with certain ferments, such as those employed in the production of koumiss and kefir.

Koumiss was originally made from mare's milk. In this country it is made from cow's milk with the addition of cane-sugar and yeast.

Kefir is a similar beverage originating in the Caucasus, where the fermentation is carried out in leather bottles and is started by means of kefir grains which contain yeasts and various micro-organisms.

The excretion of drugs and other substances in milk

The following drugs taken by the mouth have been found in the milk of nursing mothers: aspirine, iodine, mercury (calomel), arsenious acid, potassium bromide, and probably urotropine (hexamethylamine), salicylic acid and salicitates, ether, antipyrine, etc. The list of such drugs is very long. It is probable that opium and other alkaloids, all the volatile oils, purgative salts, rhubarb, and similar drugs are excreted, to a certain extent, in the milk.

It is well known how readily the flavor of milk is affected by turnips, garlic, wild onions, mouldy hay and grain, damaged ensilage, and distillery waste. The practical im-

[1] See putrefaction, p. 83.

portance of these facts is self-evident. Every nursing mother knows how careful she must be with her diet in order not to harm the baby.

Cows are good botanists, but their judgment cannot be relied upon so far as the baby is concerned. Cows in pastures may feed upon objectionable or poisonous weeds. Some of these poisons may pass into the milk. Such milk may be injurious to infants, especially in the summer-time. Herds producing certified milk are under no circumstances allowed to graze.

Advantage has been taken of these facts to reach certain conditions of the baby through the cow. Thus at one time one of our best dairymen, producing a high-grade milk for babies, found that most of the infants were constipated. This trouble largely disappeared when a portion of ensilage was added to the cow's ration.

It is generally believed that cows fed upon mouldy grain will cause diarrhœa and vomiting in persons who partake of the milk. Many such instances are on record.

Milk may contain beneficial as well as harmful substances. Thus the milk contains antitoxines, opsonins, agglutinins, lysins, and other antibodies, some of which must be of great use to the baby. It is supposed that infants raised on cow's milk have less resistance to certain diseases because cow's milk does not contain some of the protective antibodies found in mother's milk.

CHAPTER IV

DISEASES CAUSED BY INFECTED MILK

We now leave the question of dirty milk to consider that of infected milk. By infected milk we mean milk containing the specific virus of one of the infectious diseases. When infected milk is consumed raw it is very apt to become infective milk. The diseases known to be conveyed by milk are tuberculosis, typhoid fever, scarlet fever, diphtheria, sore throat, foot-and-mouth disease, malta fever, milk sickness, and occasionally others. This list does not include the dysenteries and gastro-intestinal diseases of babies that also are associated with impure milk.

Some of the diseases mentioned come from the lower animals; some from man. Thus bovine tuberculosis, foot-and-mouth disease, and milk sickness come from the cow; malta fever is primarily a disease of goats. The more serious infections in milk, however, come from human origin. Man contracts most of the diseases to which he is heir from his fellow men. Cows do not have typhoid fever, scarlet fever, or diphtheria, so that when milk contains the viruses of these diseases the infection usually gets into the milk either directly or indirectly from human sources.

When all the diseases due to impure milk are counted up the indictment is a strong one. While pointing out the dangers, we must ever be mindful of the fact that our object is not to discourage the use of milk — only to discourage the production and use of impure milk. We want to encourage the use of good milk as one of the best and cheapest foods on the market.

Milk-borne epidemics vary greatly in prevalence and severity. Only one or two persons may be involved, or the

epidemic may include several thousand. During the past four years the city of Boston has suffered severely.

RECENT MILK-BORNE EPIDEMICS IN GREATER BOSTON

1907	Diphtheria	72 cases
1907	Scarlet fever	717
1908	Typhoid fever	400
1910	Scarlet fever	842
1911	"Tonsillitis"	2064
		4095

Other cities have also been sufferers, but milk-borne outbreaks are not always reported as such. Health officers frequently tell me that they have just had or are just having a milk-borne outbreak of typhoid fever; sometimes scarlet fever; more rarely diphtheria. However, these outbreaks are not always reported, for they are becoming "twice-told tales." It is, therefore, probable that more cases of sickness are due to infected milk than appear in the official returns. Further, it is evident to students of the subject that many a milk-borne outbreak escapes recognition. Small outbreaks of two or three cases in villages and towns are often passed over as trivial occurrences. However, two cases of typhoid fever in Podunk, with a population of one thousand persons, is equivalent to two thousand cases in a city with a population of a million. Not infrequently small villages may have five, seven, or eight cases of sickness caused by infected milk. Proportionately this would be an epidemic of untold magnitude in a metropolitan city.

The character of milk-borne epidemics

The diseases which most commonly occur in epidemic form as the result of infected milk are: typhoid fever, scarlet fever, diphtheria, sore throat. These outbreaks sometimes affect only a small group of people, perhaps two or five individuals, or they may be extensive enough to in-

volve a thousand or more. They are perhaps more likely to occur in the summer-time when the milk is warm and the infection has a chance to grow. Milk-borne epidemics, however, have been traced to milk in the winter-time, and also to milk which has been kept on ice until it reached the consumer. Cold, therefore, is a preservative rather than a preventive against these dangers. Even freezing does not kill these infections.

Milk-borne outbreaks usually have an explosive onset. The disease follows the milk route. In fact, the disease may occur only among users of the infected milk. When the cases are charted upon a map the milk routes resemble thoroughfares of infection but, for several reasons, the disease is not always limited strictly to those who use the milk. The first is that a milk-borne outbreak usually occurs when the disease prevails in the neighborhood. In fact, the greater the prevalence of the infection the greater are the mathematical chances of contaminating the milk. Further, secondary cases soon occur, for each person is a focus from which the disease spreads. There is, however, a special incidence of the disease in milk drinkers. For instance, the only member of a family or the only person in a large boarding-house to be attacked will be a person drinking the raw milk; on the other hand, the only person exempt will be the sole one not using it. It is not only persons fond of milk who are apt to be attacked, for milk products also may convey the disease. Thus disease may be contracted simply by the use of a little cream in coffee or upon cereals, or the drinking of soda water containing cream, the eating of ice cream, etc.

People in the better walks of life are often attacked in greater proportion than others. This is explained by the fact that families with larger incomes are supposed to drink more milk than those with lesser resources. Among the well-to-do, therefore, it frequently happens that infected milk finds more victims, while among the poor the

children are the ones more likely to suffer. One of the greatest tragedies for the sanitarian is to see disease and death follow the trail of infected milk in households that are otherwise in prime sanitary condition. Very often the women and children suffer most in milk-borne outbreaks because they appear to be more fond of milk than men.

In reporting milk epidemics, Trask gives some of the points of special interest, as the following: —

1. The number of cases of the disease existing in the involved territory during the time covered by the epidemic.
2. The number of houses invaded by the disease.
3. The number of invaded houses supplied in whole or in part, directly or indirectly, by the suspected milk.
4. The number of cases occurring in invaded houses so supplied.
5. The number of houses supplied with the suspected milk.
6. The relative proportion of houses so supplied to those supplied by other dairies.
7. The time covered by the epidemic.
8. The location of the case or cases from which the milk became contaminated.
9. The relation of the original case to the milk.
10. The time relation of the original case to the epidemic.
11. The special incidence of the disease among milk drinkers.
12. The elimination of other common carriers of infection.
13. The effect upon the epidemic of closing the dairy or taking such measures as will eliminate possibility of milk contamination from the suspected focus.
14. The finding of the specific organism in the milk.

Tuberculosis

Of all the communicable diseases spread by milk tuberculosis takes the lead. At one time we were inclined to give first place to typhoid fever, but judged by the frequency with which tubercle bacilli occur in milk, this danger easily takes first place. It is difficult to judge of the comparative "importance" between diseases, but it is

probable that the damage caused by tubercle bacilli in milk outstrip the consequences caused by any other specific infection thus conveyed.

Tuberculosis is the most frequent and widespread of all infectious diseases, whether of man or cattle. The economic loss from tuberculosis in cattle is a matter of serious concern to the dairyman. In this country nine per cent of all human deaths and in Germany twelve per cent are caused by tuberculosis. Most people die of tuberculosis during the prime of life. In other words, thirty per cent of all deaths between the ages of fifteen and sixty are due to tuberculosis. Almost all of us have had the infection in some form or another. Careful autopsies are able to discover the consequences of the invasion of the tubercle bacillus into the tissues in almost every adult, no matter what the cause of death.

In this country it is estimated that 160,000 persons die each year of tuberculosis. Stated in another way it may be said that at least 5,600,000 people now living in this country are doomed to die of tuberculosis unless the disease is checked. The loss of life and treasure is appalling. The modern messages that tuberculosis is preventable and curable have been received with a great sigh of relief. The final control of this disease will be a crowning achievement in preventive medicine.

The difference between human and bovine tuberculosis. The human and bovine tubercle bacilli resemble each other closely. The essential differences lie in the fact that the human type is very pathogenic for man, but has little power of producing disease in cattle, rabbits, guinea-pigs, monkeys, and other animals. On the other hand, the bovine type is very virulent for almost all mammalian animals except man.

The difference between the effects of the bovine bacillus and the human bacillus in man may be better understood from the fact that the bovine infection is apt to remain

localized in the lymphatic glands (scrofula) and usually terminates favorably. On the other hand, the human bacillus is very prone to attack the lungs and cause pulmonary tuberculosis, which is the common fatal type in man. This, however, is not always the case. While the bovine bacillus is not known to attack the lungs in man it may attack the coverings of the brain, causing tuberculous meningitis, the peritoneum, causing tuberculous peritonitis, or other vital structures, resulting in death. Bovine tuberculosis may also become generalized, resulting in acute miliary tuberculosis or "galloping consumption."

The differences which the bacteriologist depends upon to distinguish a bovine bacillus from a human bacillus are based upon animal experimentation and cultural characters. Thus, when even large numbers of the human variety are injected into a calf a general disease does not result: at most there is only a local lesion. On the other hand, calves are very susceptible to injections of bovine cultures. A small quantity (0.001 gram of pure culture) of a bovine strain injected subcutaneously into a rabbit is sufficient to cause generalized tuberculosis and death of the animal in about six weeks. Ten times this amount of a human strain produces at most a slight localized tuberculosis. The human bacillus grows well upon artificial culture media, covering the entire surface of the medium with a rich, dry, crinkled, mould-like vegetation. The growth of the bovine bacillus upon artificial culture media is more sparse, thinner, less extensive, and somewhat slower. The human bacillus usually produces more acid in artificial culture media, with a different reaction curve from the bovine bacillus. The two types cannot be distinguished from each other under the microscope, although the human bacillus is frequently longer, club-shaped, and stains intermittently, while the bovine type is often shorter, straighter, more regular, and stains solidly.

How tubercle bacilli get into milk. Bovine tubercle bacilli usually get into the milk in one of three ways: —

(1) Directly: from a cow with tuberculosis of the udder, in which case the milk contains large numbers of tubercle bacilli as it flows from the teat.

(2) Indirectly: from a cow having tuberculosis of the lungs. In this case the tubercle bacilli are coughed up into the mouth, swallowed by the cow, passed in the fæces, and thus indirectly get into the milk.

(3) The milk from healthy cows may contain tubercle bacilli from admixture with other milk or from contamination with tuberculous material.

Human tubercle bacilli occasionally get into the milk from persons having pulmonary tuberculosis. Such persons could contaminate the milk by coughing, sneezing, or through infected hands, contaminated cloths, or unsanitary actions. Hess actually found human tubercle bacilli in a sample of New York market milk.

In order for the bovine tubercle bacillus to contaminate milk it is necessary that the tuberculosis in the cow should be an open process; that is, the bacilli must be discharged into the environment. The tubercle bacilli that are locked up in a lymph gland, or in the nodules upon the peritoneum, or in the bone or lung, or any other portion of the body, do not endanger the milk supply. Experiments have shown that it is more than probable that the healthy mammary gland is an efficient filter so far as the tubercle bacillus is concerned. Even when tubercle bacilli are in the blood they probably do not pass through into the milk, unless the udder is diseased. It is some comfort to know that in tuberculosis, the bacilli do not frequently invade the blood, and that if they do so a healthy mammary gland may be depended upon to filter them out.

Of the various sources of tubercle bacilli in milk the most serious is tuberculosis of the udder. This is for the reason that incredibly large numbers of active virulent tubercle

bacilli appear in the milk when this condition is present. It is estimated that about one to two per cent of all cows with tuberculosis have udder tuberculosis. It is usually the left hind quarter of the udder that is involved. Sometimes the cow has tuberculosis of the udder, while no other part or organ is involved. As a rule tuberculosis of the udder is secondary to tuberculosis of some other gland or tissue. The disease, when it is fully developed in the udder, may usually be recognized by feeling the hard inflammatory nodules and by noticing the abnormal appearance of the secretion from the diseased quarter. In udder tuberculosis the appearance of the milk remains unaltered for a long period, although it contains tubercle bacilli. Only very small flakes are intermixed with it. Later on it decreases in quantity, grows thinner, and contains more flakes. When fully developed, the secretion obtained from the diseased quarter no longer resembles milk, but is a slimy, mucopurulent, creamy, or cheesy substance. A minute fraction of a drop of this secretion may be sufficient to cause fatal tuberculosis in a guinea-pig. The other three quarters of the udder may not be involved at all.

The milk from a tuberculous udder of one cow may be sufficient to contaminate seriously the milk from a herd of twenty-five or thirty cows. In a certain instance Ostertag found that one millionth of a cubic centimetre of the secretion from a tuberculous udder was sufficient to cause tuberculosis in a guinea-pig. A child would drink in six ounces an enormous dose in such a case. The tubercle bacilli in the secretion of many a case of tuberculosis of the udder are quite as numerous, under the microscope, as they are in tuberculous sputum.

Schroeder has pointed out the danger of infecting milk, from cows having pulmonary tuberculosis, through the fæces. Milk obtained by the ordinary methods contains an appreciable quantity of cow fæces; sometimes excessively large amounts. This is one of the ways in which tuber-

culosis is therefore spread, not alone from cow to man, but from cow to cow, from cow to hog, etc.

How frequently does milk contain tubercle bacilli? Ordinary market milk so frequently contains tubercle bacilli and in such large numbers as even to surprise the research workers in laboratories who busy themselves with these questions.

Tonney examined the market milk of Chicago in 1910 for the presence of tubercle bacilli. In 10.5 per cent of 144 samples of raw milk he found tubercle bacilli in sufficient numbers to infect guinea-pigs. Of 19 samples of pasteurized milk examined, none contained tubercle bacilli.

Hess in 1909 examined 107 samples of market milk in New York City, with the result that 17 of them, or 16 per cent, were found to contain tubercle bacilli.

Anderson examined 233 samples taken in the city of Washington and reported 16, or 6.72 per cent, as positive. The tests made by the Bureau of Animal Industry of the milk in Washington disclosed 7.7 per cent infected. Goler reports about 5 per cent of the milk supply of Rochester, New York, infected.

TUBERCLE BACILLI IN MILK

	Investigator	Samples examined	Per cent containing tubercle bacilli
Chicago (1910) . . .	Tonney	144	10.5
New York (1909) . .	Hess	107	16.0
Washington (1906). .	Anderson	233	6.7
(1907–1908)	Bureau of Animal Industry		7.7
Rochester	Goler		about 5.0

To sum up, we have evidence from four typical American cities. A total of 551 samples of milk have been examined in which tubercle bacilli were found in 46, making a percentage of 8.3. This may be taken as the average percentage for the entire country. As a matter of fact the incidence

of tubercle bacilli in milk would be much higher than this if our methods for their detection were more delicate.

Professor Delepine found that the milk sent by rail to Manchester from 272 farms contained tubercle bacilli from 26, or 9.5 per cent. Wherever these investigations have been carried out, similar results have been obtained both in Europe and in this country. It is clear that the common market milk furnished all large cities, and probably most small towns, very often contains tubercle bacilli.

William G. Savage[1] submits interesting figures showing the number of samples of milk in English cities containing tubercle bacilli during the past ten years. The Manchester figures are the most important, as they deal with a very large number of samples extending over a series of years. The table shows that there has been some diminution in the percentage of tuberculous samples, but this diminution has not been continuous or very marked. Thus the amount of tuberculous milk for Manchester drops to about six per cent, and to about nine per cent for Sheffield, and there it remains. It is therefore evident that the English method of dealing with bovine tuberculosis is a failure so far as may be judged by the figures in the following table: —

TUBERCLE BACILLI IN MIXED MILK SAMPLES (PERCENTAGES)

	1901	1902	1903	1904	1905	1906	1907	1908	1909	1910
1 Manchester	8.7	8.57	10.42	6.7	6.15	6.2	5.74	8.28	5.14	..
2 Liverpool—Country samples	6.1	7.3	5.1	9.2	3.8	6.8	4.7	3.3	1.8	4.1
2 Liverpool—Town samples	0.6	0.4	0.8	1.5	0.4	1.4	1.5	2.0	0	1.4
3 Sheffield—Country samples	..	17.8	16.7	6.7	14.7	9.6	9.7	9.9	10.9	10.4
4 Birmingham — Country samples	..	...	prior	to1908	=14	%	..	11.3	7.5	7.3
5 Leeds—Country samples.	..	...	....	....	....	...	..	25.3	16.4	..
6 Sunderland	..	...	....	....	....	...	2.5	7.0	7.4	3.6
7 London (L. C. C.)	..	...	....	....	....	...	..	11.6	10.4	..

If the bovine tubercle bacillus is dangerous to man, we are, then, face to face with a real hazard. We must, there-

[1] *Public Health*, no. 4, vol. xxv, Jan., 1912, p. 128.

fore, consider the relation of bovine tuberculosis to human tuberculosis.

The relation of bovine tuberculosis to human tuberculosis. When Koch first discovered the tubercle bacillus, in 1882, he stated that he considered tuberculosis an identical infection both in man and cattle. This view was generally accepted by scientists as well as by the public. In 1896 Professor Theobald Smith, then of the Bureau of Animal Industry at Washington, called attention to the fact that the human tubercle bacillus has certain marked characteristics by which it may be differentiated from tubercle bacilli found in lower animals. Koch developed the comparative study of the different types of tubercle bacilli and in 1901, at the Congress on Tuberculosis, made his startling announcement — that human tuberculosis and bovine tuberculosis are two separate and independent diseases, and that there is practically no danger of man contracting tuberculosis from cattle. Koch's dictum was based upon incomplete and unsatisfactory evidence. The effect of Koch's statements was to stimulate work which has thrown a flood of light upon the subject. Several government commissions were appointed in different countries and many scientists immediately took it upon themselves to solve the questions raised. The results of all these experiments, which have been going on during the past ten years, are singularly unanimous in their conclusions. They all show that human beings, especially children, may become infected with tuberculosis from cattle. As soon as this question was definitely settled, the next problem was to determine how frequently this infection takes place and how serious a public health problem it is.

The German Commission on Tuberculosis examined fifty-six different cultures of tubercle bacilli obtained from human beings and found six of them of the bovine type; that is, over ten per cent. In a similar series of tests con-

ducted by the British Royal Commission on Tuberculosis, sixty cases of the disease from human beings were examined, with the result that fourteen proved to be infected from bovine sources. Ravenal, Theobald Smith, and others added like testimony, but by far the largest and most valuable series of cases were studied by Park and Krumwiede, of the Research Laboratory of the Department of Health of New York City. Park, Krumwiede, and their associates determined the nature of the tubercle bacilli in 436 cases of tuberculosis in human beings. Of the persons examined 297 were over sixteen years of age, and in these cases only one, which happened to be a case of renal infection, gave bacilli of the bovine type. Of the 297 cases examined in persons over sixteen years of age, 278 had pulmonary tuberculosis. The figures were quite different in the cases examined under sixteen years of age. Thus, of fifty-four cases of children between five and sixteen years, nine had the bovine bacillus. Still more striking are the figures in young children. Thus, twenty-two out of eighty-four cases under five years of age had the bovine bacillus.

In all, 1040 cases of human tuberculosis have been similarly studied. In not a single case of pulmonary tuberculosis in this series have bacilli of undoubted bovine type been found.[1]

A large proportion of the human cases infected with the bovine type consists of infection of the abdomen, or of the glands of the neck.

The fact that bovine tuberculosis is frequently fatal, especially in children, may be divined from the fact that fifteen per cent of the fatal cases of tuberculosis in children under five years of age that have been studied, were due to the bovine type of bacillus. To sum up: From five to seven per cent of all human tuberculosis is ascribed to infection with the bovine bacillus. Further, bovine tuberculosis

[1] In one or two instances not included in these figures the bovine tubercle bacillus has been found in pulmonary consumption.

probably causes one fifth to a fourth of the tuberculosis of infancy and childhood.

It thus becomes evident, from the results which have been briefly outlined here, that the bovine type of tubercle bacillus plays a significant part in the etiology of tuberculosis in children, and that the effort to prevent this disease clearly must include the bovine sources.

Bovine tuberculosis in man is practically always ingestion tuberculosis; that is, the infection is taken into the mouth, passes through the digestive tract, and invades the glands and tissues of the body. We now know that the tubercle bacillus may pass through the mucous membrane without leaving a trail behind it.

That, however, there is another side to this much discussed question is evidenced by the recent observations in Germany. The Imperial Board of Health of Germany has made observations to determine just how much danger there is in drinking milk containing bovine tubercle bacilli. The milk coming from all known cases of udder tuberculosis was traced to the consumer and all the persons drinking such milk or using fresh milk products from infected sources were examined with reference to tuberculosis. In all, one hundred and thirteen separate investigations were made, including six hundred and twenty-eight persons (two hundred and eighty-four of whom were children, three hundred and thirty-five were adults, and nine of unstated age), all of whom had undoubted opportunities of consuming milk or fresh milk products from cows having tuberculosis of the udder. The evidence presented is not equally valuable in each investigation. In forty-four of the one hundred and thirteen investigations cited, the milk was either heated, used in coffee or tea, or mixed with milk from apparently tuberculosis-free cows before it was consumed.

Three hundred and sixty persons (of whom one hundred and fifty-one were children, two hundred adults, and

nine of unknown age) were known to use milk or milk products, such as butter, buttermilk, sour milk, and cheese, which came from cows having undoubted tuberculosis of the udder. Of these three hundred and sixty persons, two were shown, by actual animal experimentation, to have infections with the bovine tubercle bacillus. Both positive cases were children with tuberculous neck glands. Six other children and one adult had glandular swellings in the neck, and in four other children and one adult there was a strong suspicion on the part of the attending physician that abdominal tuberculosis was present.

In another series of three hundred and sixty persons, twelve children and one adult had swellings of the lymph glands of the neck. In this group the diagnosis was not confirmed bacteriologically.

Weber concludes from these studies that the danger which man undergoes through the consumption of uncooked milk and milk products of cows having tuberculosis of the udder is similar to the danger which persons having well-marked pulmonary tuberculosis exhibit for their fellow men, although very much less. He believes it is fair to assume, from the statistics presented above, that the danger from drinking uncooked milk or using milk products of cows with tuberculous udders is surprisingly small.

It will take many years and patient observation to interpret these results. Meanwhile it is safe to assume, with the evidence before us, that no one would willingly drink milk or partake of fresh milk products known to contain tubercle bacilli — much less permit babies to use such stuff as food.

In rare instances butchers, pathologists, and others contract bovine tuberculosis, especially of the hands, by infecting themselves through wounds of the skin.

The prevalence of tuberculosis among dairy herds. In general, it may be stated that tuberculosis is about as prevalent in milch cows as it is in man. The distribution also

corresponds, in that cows kept under unsanitary conditions are much more apt to become infected than those that live an outdoor life, with good food, etc.

The percentage of tuberculosis in cattle varies greatly with the refinements of diagnosis. Thus the percentage of reactors to the tuberculin test would be very much greater than the percentage showing clinical manifestations of the disease.

The New Jersey Tuberculosis Commission found something like sixteen per cent of the cattle examined to be suffering from tuberculosis. In Saxony no less than thirty per cent of all cattle are believed to be infected by this disease. In Copenhagen, Professor Bang has shown the disease to be very prevalent. In Denmark, the percentage is estimated at about seventeen per cent. In Leipzig, thirty-three per cent of the cattle over one year old slaughtered in 1895 were found to be tuberculous.

Fifteen to twenty-five per cent of all the cows supplying the District of Columbia have tuberculosis, according to estimates of government officials. Perhaps a similar percentage applies to the cattle supplying the milk of other large cities. There is much more tuberculosis in some parts of the country than in others. As we go west we find less tuberculosis among the cattle who live a natural life upon the ranges. The disease increases when cattle are imprisoned in stables, with poor air, lack of exercise, exposure to infection, and other unsanitary conditions. For the same reason the most tuberculosis in human beings occurs in crowded quarters and where people live under bad hygienic conditions.

Tubercle bacilli in milk products. When tubercle bacilli are present in milk they collect in about equal proportions in the cream and sediment. This is equally true when cream separates slowly and naturally (gravity cream), or when it is forced to the surface quickly by the use of a centrifugal machine (separator cream). Tubercle bacilli

may therefore pass from milk to cream and from cream to butter. Schroeder has, in fact, shown that some of the butter sold by dealers is very badly infected. According to European investigators butter is more frequently infected than milk. Schroeder estimates that butter contains tubercle bacilli in sufficient numbers for their detection thirteen times for every ten times that they can be found in milk. The reason for this is now perfectly evident.

Investigators upon this special subject have found tubercle bacilli to remain alive in butter a variable length of time. Thus, Laser, twelve days; Heim, thirty days; Gasperini found a reduction of virulence after thirty days; but Dawson observed no reduction of virulence until three months, and found the bacilli still alive in butter eight months old. Broers found that tubercle bacilli will live three days in milk, even when it has undergone changes that make it unfit for use as food, twelve days in buttermilk, and at least three weeks in butter. Schroeder found no appreciable attenuation of tubercle bacilli in ordinary salted butter in forty-nine days; that they were still highly virulent after ninety-nine days, even though the butter had become rancid and mouldy; and that they were alive and capable of causing fatal tuberculosis in guinea-pigs after one hundred and thirty-three days. Mohler found that tubercle bacilli remained alive one hundred and fifty-three days in butter held in cold storage under ordinary commercial conditions.

Cheese has also been found to contain tubercle bacilli. In it they may live from thirty to forty days. The kinds most dangerous are naturally the fresh cheeses, such as cottage cheese. Cheeses which ripen slowly probably contain no living tubercle bacilli when they reach the consumer.

We can draw no consolation from the fact that certain kinds of oleomargarine, which is much used as a substitute

for butter, may be free from the danger in question. Oleomargarine may become infected in two ways: by fat derived from tuberculous animals, or by butter and sour milk that sometimes enter into its composition. Morgenroth examined twenty samples of oleomargarine purchased in the open market and found that nine of them contained virulent tubercle bacilli.

It is perfectly plain, therefore, that cream, ice cream, butter, cheese, and other milk products are a source of danger to man so far as tuberculosis is concerned, for these articles not only contain tubercle bacilli, but some of them contain the infection in concentrated form.

The prevention of bovine tuberculosis. There are two clearly defined methods by which man may protect himself from the dangers of bovine tuberculosis. One is the elimination of tuberculosis from cattle: the other is pasteurization. The elimination of bovine tuberculosis in cattle is a large undertaking, but may successfully be accomplished in isolated herds, in a reasonably short time, through the aid of the tuberculin test, and by the information derived from physical examination. Until the milk supply is derived from tuberculin-tested cows or from milch cows known to be free of infection, our only protection is pasteurization. A temperature of 60° C. (140° F.) for twenty minutes kills tubercle bacilli and renders them entirely harmless.

The bovine tubercle bacillus is transmitted from cattle to man, in the great majority of cases, through milk. So infrequently does it come to us through the meat or other beef products that we may almost ignore all, except milk, from a public health standpoint. Tuberculosis of the muscles is very rare; furthermore, meat is usually cooked. The heat of cooking gives us a similar protection in eating tuberculous liver or other glands. Finally, the system of meat inspection which is carried on in this country is an additional safeguard.

If all the tuberculosis were eliminated from cattle, or if all the milk in all the world were pasteurized, there would still be an enormous amount of tuberculosis left. In fact, the diminution in the number of deaths from tuberculosis through this one measure alone would be disappointingly small. In other words, the more serious type of tuberculosis in man is very largely a disease contracted from man. In Japan, for example, where milk is not used at all as an article of diet, there is quite as much tuberculosis as there is in Europe or this country. In the tropics, where practically all the milk is boiled, tuberculosis is very prevalent. It must nevertheless be remembered that the number of deaths and the amount of sickness caused in man from bovine tuberculosis is enormous in the aggregate.

The tuberculin test. There are several methods of detecting tuberculosis in cattle, but the quickest and surest is the tuberculin test. It is a matter of common observation that a cow may be fat and sleek, eat and milk well, have a bright glossy coat, and be apparently in the pink of condition, and still be passing tubercle bacilli from an infected udder, or the infection may appear in the fæces as a result of an occasional cough. As a matter of fact, milch cows, during a certain stage of tuberculosis, often furnish a large yield of milk.

Before tuberculosis can be eliminated, it must first be detected. There are two methods by which the disease may be diagnosed. One is through physical examination and the other by the tuberculin test. Compared with each other the diagnosis by physical examination is crude, unsatisfactory, and inaccurate, while the diagnosis with tuberculin is refined, delicate, and precise.

The substance known as tuberculin was discovered by Koch in 1890. Tuberculin is made by growing a pure culture of tubercle bacilli in bouillon, which is then sterilized by heat and the dead bacilli filtered out. Koch's tuberculin, therefore, does not contain the bacilli themselves,

and, contrary to prevailing opinion, it is impossible to produce tuberculosis with tuberculin.

Tuberculin is a chemical substance which is quite harmless to a normal animal, but produces a reaction in an animal having tuberculosis. The principal diagnostic feature of this reaction consists in a rise of temperature.

The tuberculin test is an exceedingly delicate one. This is both an advantage and a disadvantage. The advantages are evident. The disadvantage consists in the fact that the test is so refined that it does not distinguish between a slight localized lesion — which may be locked up in a gland and never cause the animal further trouble — and a massive, progressive, or generalized type of the disease. This fact has caused considerable confusion and some prejudice in the minds of the farmer with the tuberculin test. One of his cows reacts typically after an injection of tuberculin. The animal is killed and examined and the only tuberculosis found is a small focus the size of a pea in one of the lymph glands of the chest. It is true that such a cow might furnish a safe milk for years; nevertheless it is impossible to tell when such a focus may break its bounds and spread. The only way to eliminate the disease from a herd is to get rid of every vestige of it: a single spark left may be sufficient in time to produce an epidemic.

The tuberculin test is one of the most reliable reactions of its kind in biology. An accurate diagnosis may be established in over ninety-seven per cent of the cases tested. The three per cent of failures occur both in cattle with tuberculosis which do not react, and in cattle without tuberculosis which do react. A cow may have tuberculosis and fail to react, especially if in the last stages of the disease, and occasionally in the very first stages. Sometimes tuberculous animals fail to react because they have had a previous injection of tuberculin within six weeks. This fact is sometimes used by unscrupulous persons to trick the inspector, by giving an injection of tuberculin sev-

eral weeks before the official tests are made. When cows that are not tuberculous show an elevation of temperature after an injection of tuberculin it is usually the result of advanced pregnancy; excitement; inflammatory febrile diseases; inclosure in a hot stuffy stable, expecially in summer; or some change in the method of feeding, watering, and stabling of the animal during the test. Many of these errors are avoided by a skilled veterinarian.

The following directions for making the tuberculin test are given by Mohler: —

(1) Stable cattle under usual conditions and among usual surroundings, feeding and watering in the customary manner.

(2) Make a physical examination of each animal, and give to each one some designation by which the animal will be known throughout the test.

(3) Take each animal's temperature at least three times at two or three hour intervals on the day of injection; for instance, at 2, 5, and 8 P.M.

(4) At 8 or 10 P.M. inject a dose of tuberculin under the skin in the region of the shoulder, using a sterile hypodermic syringe after disinfecting the skin at the seat of injection with a five per cent solution of carbolic acid or a similar antiseptic solution.

(5) Tuberculin is not always concentrated to the same degree, and therefore the dose, which should always appear on the label, varies considerably. The dose of imported tuberculin is 0.25 cubic centimetre for an adult cow, and before injection is diluted with sterile water, 2 cubic centimetres. The tuberculin made by the Bureau of Animal Industry is prepared so that it will not be necessary to dilute it, and the dose is 2 cubic centimetres for an adult animal. Yearlings and two-year-olds, according to size, should receive from 1 to 1.5 cubic centimetres, while bulls and very large animals may receive 3 centimetres.

(6) At 6 A.M. on the day following the injection of tuberculin, commence taking temperatures, and continue every two or three hours until the twentieth hour after injection, at which time if there is no tendency for the temperature to rise the test may cease.

(7) A rise of 2° F. or more above the maximum temperature observed on the previous day, providing the temperature after injection exceeds 103.8° F., should be regarded as an indication of tuberculosis. Those cases which approximate but do not reach this standard should be considered as suspicious, and held for a re-test six weeks later, giving double the original dose.

The legal status of the tuberculin test. The recent decision of the court in the case of the Borden Condensed Milk Company *versus* the Board of Health of the Town of Montclair, New Jersey, is illuminating and shows the march of progress. This decision was handed down by Justice Swayze, June 6, 1911. The Borden Condensed Milk Company endeavored to set aside a portion of Article 8 of the Sanitary Code of Montclair relating to milk and its production. The portion complained of reads as follows: —

No milk shall be sold or offered for sale or distributed in the Town of Montclair except from the cows in good health, nor unless the cows from which it is obtained have within one year been examined by a veterinarian whose competency is vouched for by the State Veterinary Association of the state in which the herd is located, and a certificate signed by such veterinarian has been filed with the board of health, stating the number of cows in each herd that are free from disease. This examination shall include the tuberculin test, and charts showing the reaction of each individual cow shall be filed with this board. All cows which react shall be removed from the premises at once if the sale of milk is to continue, and no cows shall be added to a herd until certificates of satisfactory tuberculin tests of said cows have been filed with this board.

The board of health may, from time to time, when in its opin-

ion the public interest may require, permit, by resolution, the sale of milk that is produced under conditions other than as herein specified, provided that such milk is pasteurized by subjecting it to a temperature of 150° F. for twenty minutes, or by an equivalent process.

No cream shall be sold, exposed for sale, or delivered within the Town of Montclair, unless it is produced and handled in accordance with the requirements hereinbefore set forth for the production and sale of milk.

One of the arguments was that the Sanitary Code of Montclair makes the right to sell milk dependent not upon the fact of the existence of disease in the cow, but upon the result of a specific method of diagnosis — the use of the tuberculin test. The court found that the tuberculin test is the most reliable method of diagnosis in cattle now known; and while it is not perfect, the percentage of error is as small as any method suggested; and that it is more accurate than the method of physical examination. The court reached this conclusion not merely upon the testimony in the case, but upon the fact that it has been approved by judicial decisions in Minnesota, Louisiana, Wisconsin, and Pennsylvania.

Further, the tuberculin test has been adopted by recent statute in Delaware, Indiana, Maryland, Michigan, Minnesota, New Mexico, North Dakota, Oregon, Pennsylvania, South Carolina, Tennessee, Washington, and Wisconsin, and for some purposes by Maine, Massachusetts, and Vermont. The tuberculin test is also referred to in the Acts of South Dakota and New Jersey.

These statutes are legislative testimony, of cumulative force, to the value of the tuberculin test as a diagnostic agent. The court, therefore, considered that the board of health is justified in the position that cattle which react to the tuberculin test are diseased. It was recognized that such a conclusion may occasionally be erroneous, but it is as nearly accurate as is possible.

The Borden Company also objected to the ordinance for the reason that it goes farther than is necessary for the protection of the public, and hence farther than is warranted by any power that can be given by a statute that by its title relates only to health. The court does not accede to this argument, and says that "to protect the public against danger from impure milk some practicable method of ascertaining its purity must be devised." The court further recognized that one of the most serious dangers that may arise is the spread of a communicable disease such as tuberculosis. That the ordinance is not necessarily oppressive is proved by the ready compliance therewith by the other milk dealers in Montclair.

The court was not impressed by the suggestion that healthy cows may and diseased cows may not react to the tuberculin test; that many cows react that have had tuberculosis and recovered; that many that now have tuberculosis are likely to recover; and that it is possible for the producer of milk to destroy the value of the test by a trick.

The court further believed that it is beside the point to suggest that if this test were applied to human beings, eighty per cent of mankind must be condemned as diseased. Judge Swayze said, "In dealing with human beings a different rule is followed from that which is applied in dealing with cattle, because men make the rule. The test might be applicable to human beings if it were proposed to use the produce of their bodies as food for others. A wet-nurse might probably be subjected to a more stringent examination."

The court fully considered the validity of this legislation under the Federal Constitution and compared it with the constitutionality of the Compulsory Vaccination Act of Massachusetts and other similar acts to protect the public health.

Surely milk from cattle that react to a tuberculin test has been exposed to disease, and if the cattle themselves may be kept

out of the state it is fairly within the discretion confided with boards of health to exclude also milk, the produce of cattle, which it has proved at times may convey disease.

Great as is the power confided in boards of health, it must stop short of arbitrary action and the means must bear some reasonable relation to the protection of public health. The Montclair Board of Health has been careful to avoid arbitrary action.

It gave the Borden Company ample time so that the farmers from whom it derives its milk might comply with the regulation, and further, the board was fair to the producers in that it provided an alternative, namely, pasteurization. The court concluded that the ordinance in question is valid.

The conclusion is inevitable. Raw milk from cows having tuberculosis should not be sold.

Tuberculosis in hogs. The question of tuberculosis in hogs is exceedingly interesting in its relation to tuberculosis in cattle. Hogs are very susceptible to tuberculosis and are apt to contract the infection either by drinking milk containing tubercle bacilli or by being permitted to feed upon cow fæces containing the same. In recent years the custom has grown for certain dairies to use skim milk and for cheese factories to use the whey, by feeding it to hogs. This practice has resulted in a marked increase in the amount of tuberculosis in hogs so fed. To such a marked degree has this become that buyers have learned to avoid certain districts on this account. In any event, the price paid is lower in anticipation of losses from condemned carcasses or parts. In the corn belt, pigs are raised by allowing them in the fields with cattle. There they feed upon the droppings which, as we know, frequently contain tubercle bacilli. Such swine have an unusually large percentage of tuberculosis. All this tuberculosis in swine is ingestion tuberculosis; that is, affects especially the glands and internal organs draining from the digestive tract.

Typhoid fever

Of the diseases which occur in epidemic form as a result of infected milk, typhoid fever is the most frequent. In fact, with a clean water supply milk is almost the only remaining medium capable of causing violent and extensive outbursts of this disease. Oysters and other foods partaken raw are responsible occasionally for small outbreaks.

The typhoid bacillus grows well in milk. Therefore, if a small particle of matter containing this micro-organism, or even if one typhoid germ accidentally gets into milk, it may undergo rapid multiplication and soon become disseminated throughout the mass. The typhoid bacillus is actively motile so that every drop of the milk will contain some of these micro-organisms if it is infected; a tumblerful of milk may contain countless myriads.

Milk may appear to be perfectly fresh and sweet and yet contain vast hordes of typhoid bacilli. In fact, this micro-organism grows and multiplies in milk without producing any material change in its color, odor, taste, or appearance. Therefore the danger is insidious, and the phrase that "typhoid lurks in milk," while trite and unpleasant, is nevertheless true. In view of the tremendous multiplication which can take place in milk, especially when it is warm, it is easy to appreciate how one bottle or less of infected milk taken into a dairy may, when mixed with a large volume, convey the infection to several thousand persons. We have the instance of the Boston epidemic of 1908, which caused over one thousand cases from a single source of contamination.

It is not milk alone but fresh milk products that are occasionally responsible for typhoid fever. The disease has been traced to infected ice cream, butter, and cream. We know that the process of freezing does not destroy the typhoid bacilli. In our experience in Washington several

cases of the disease were definitely traced to ice cream. Bruck has shown that typhoid bacilli may live as long as twenty-seven days in butter made from milk containing typhoid bacilli. According to Washburn the bacillus lives as long as sixty days or more. Buttermilk, of course, would be fully as dangerous as the milk or cream, from which it was separated. The time required for the ripening of cheese makes the chances of infection from this dairy product very slight. Nevertheless fresh cheese, such as cottage cheese, may contain the infection.

Milk becomes infected with the typhoid bacillus sometimes at the dairy, sometimes at the corner grocery, sometimes in the home; occasionally it becomes infected during transportation.

To show what great chances the milk has of becoming infected at the dairy we may again cite our Washington experience. The city of Washington, for example, obtains its milk supply from about one thousand dairy farms. Estimating the average number of persons living on a dairy farm at about seven, we have some seven thousand persons who have more or less intimate relation with the production of the milk. Now, considering the fact that each year in the United States about one person in every three hundred has typhoid fever, some twenty-five cases per year may be expected on the dairy farms supplying Washington with milk.

Bolduan estimates that from three hundred to four hundred cases of typhoid fever each year come in contact with the milk supplied New York City. He further states that "the startling total of ninety to one hundred and twenty typhoid carriers now probably menace the milk supply of this city." This estimate is based upon the fact that about two hundred thousand persons come into more or less contact with the milk from over forty thousand dairy farms.

Frequently the cases are mild and not recognized,

and almost always a person has typhoid fever for a week or ten days before he takes to his bed, and during this time the disease is communicable. Even when the patient on the dairy farm has nothing to do with the milk, there is

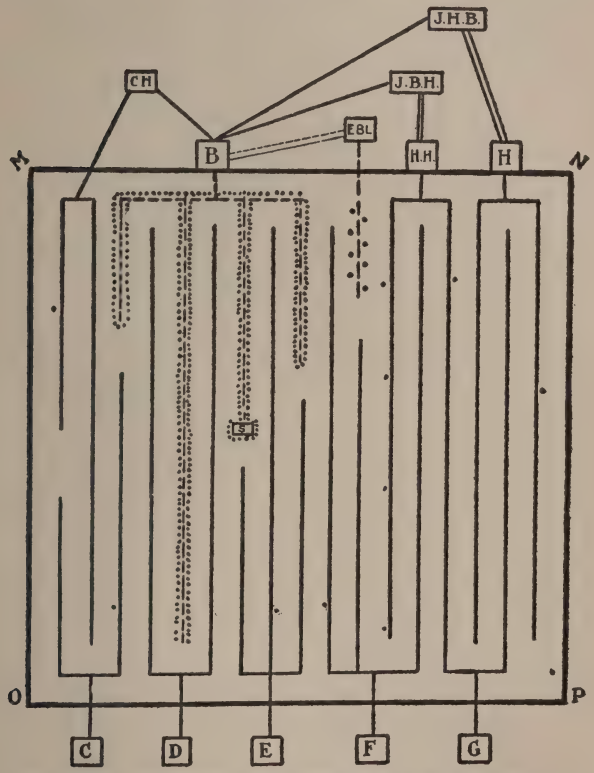


DIAGRAM SHOWING RELATION OF MILK ROUTES TO TYPHOID FEVER CASES DURING THE EPIDEMIC AT STAMFORD, CONN., 1895

considerable danger of the infection being carried to the milk if the greatest precaution is not taken with the disposal of the fæces and urine. The danger from bacillus carriers will be considered separately.

Bacillus carriers. From two to four per cent of all persons who have typhoid fever become chronic bacillus carriers; that is, they continue to discharge typhoid bacilli in their fæces or urine. A bacillus carrier may enjoy robust and vigorous health, so that it is impossible to detect these persons except by a bacteriological examination.

Recently a number of milk-borne outbreaks of typhoid fever have been traced to infection from bacillus carriers. One of the first instances was reported by Albert. This outbreak occurred in October, 1907, at Cedar Falls, Iowa, in which thirteen cases occurred in the three families supplied with the suspected milk. The man who owned the cow and did the milking had had typhoid fever one year previous to the outbreak. Typhoid bacilli were demonstrated in his urine.

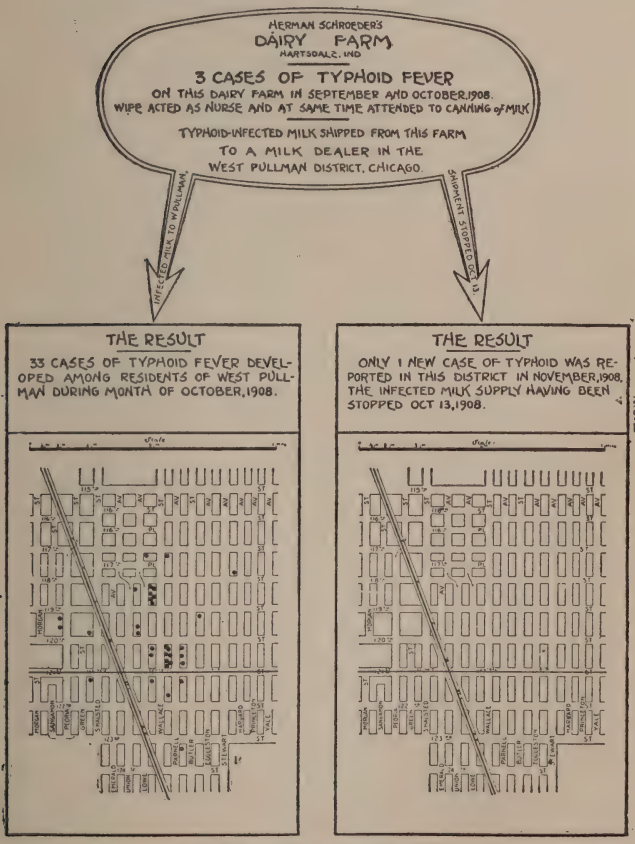
Lumsden and Woodward reported an outbreak which occurred in Washington, D.C., in September and October of 1908. Fifty-four cases occurred in this epidemic. The victims were among the customers of two different dairymen, both of whom, however, received a part of their milk supply from a certain farm. All the evidence pointed to this farm as the source of the infection in the milk. No history of recent illness on the farm could be ascertained. A search for bacillus carriers among the persons on the farm was made and one was discovered. The bacillus carrier proved to be a woman who had had an attack of typhoid fever about eighteen years before the time of the outbreak. Typhoid bacilli were found in large numbers in her fæces.

Scheller traced a typhoid fever outbreak near Königsberg, Germany, to a woman excreting typhoid bacilli in her stools and urine. This woman had had an attack of typhoid fever seventeen years before and was the source of infection for the outbreak.

Numerous other similar outbreaks have been studied in recent years. This represents one of the hidden dangers and one of the greatest difficulties in obtaining raw milk

free from danger. Cleanliness and care may, in a large measure, prevent infection from a bacillus carrier, but in the long run is no absolute guaranty. This is one of the reasons why even certified milk occasionally cannot be trusted. Further, this gives force to the statement frequently made that raw milk is apt to be dangerous milk.

A LOCALIZED EPIDEMIC OF TYPHOID FEVER
DUE TO AN INFECTED MILK SUPPLY


HERMAN SCHROEDER'S
DAIRY FARM
HARTSDALE, IND
3 CASES OF TYPHOID FEVER
ON THIS DAIRY FARM IN SEPTEMBER AND OCTOBER, 1908.
WIFE ACTED AS NURSE AND AT SAME TIME ATTENDED TO CANNING OF MILK
TYPHOID-INFECTED MILK SHIPPED FROM THIS FARM
TO A MILK DEALER IN THE
WEST PULLMAN DISTRICT, CHICAGO.
INFECTED MILK TO WEST PULLMAN
SHIPMENT STOPPED OCT 13
THE RESULT
33 CASES OF TYPHOID FEVER DEVELOPED AMONG RESIDENTS OF WEST PULLMAN DURING MONTH OF OCTOBER, 1908.
THE RESULT
ONLY 1 NEW CASE OF TYPHOID WAS REPORTED IN THIS DISTRICT IN NOVEMBER, 1908, THE INFECTED MILK SUPPLY HAVING BEEN STOPPED OCT 13, 1908.

DEPARTMENT OF HEALTH, CHICAGO.
EDUCATIONAL SERIES-No. 13

The characteristics of milk-borne typhoid outbreaks. The characteristics of a typhoid outbreak due to milk have been summed up by George Newman as follows: —

(*a*) There is a special incidence of disease upon the track of the implicated milk supply. It is localized to such area.

(*b*) Better-class houses and persons generally suffer most.

(*c*) Milk drinkers are chiefly affected, and they suffer most who are large consumers of raw milk.

(*d*) Women and children suffer most, and frequently adults suffer proportionately more than children.

(*e*) Incubation periods are shortened.

(*f*) There is a sudden onset and rapid decline.

(*g*) Multiple cases in one house occur simultaneously.

(*h*) Clinically the attacks of the disease are often mild. Contact infectivity is reduced and the mortality rate is lower than usual.

My experience with the epidemiology of typhoid fever has taught me that it is comparatively easy to detect a milk-borne outbreak in its early stages. A very suggestive sign is the occurrence of several cases at the same time in a family, especially among the women and children. Thus I have in mind a family of six children in which four of them, with the mother, came down with typhoid fever within a period of five days. In a city having a clean and satisfactory water supply such an incident throws suspicion upon the milk, for there is hardly any other single food that will cause an outbreak of this character. If health officers keep a card index system of each case of typhoid fever in relation to the milk dealers, it is easy to detect whether or not a particular milk dealer is having an undue proportion of cases among his customers. This is another way by which a typhoid outbreak may be detected during its early stages.

Scarlet fever

We do not know the cause of scarlet fever, but are quite convinced that it is a germ disease transmitted from person

to person in very much the same way as diphtheria is communicated. The virus is contained in the discharges from the nose and mouth. The virus is also contained in the discharges from the ear, and other complications which frequently are a result of an attack of scarlet fever. Scarlet fever is sometimes so mild that it is exceedingly difficult to recognize. It is these "missed" cases which are particularly dangerous. Milk is a rather frequent vehicle for scarlet fever infection.

The milk is practically always contaminated from human sources. There is, however, some suspicion that streptococcal diseases of the cow may, in some instances, be identical with scarlet fever: this is doubtful. It appears, however, that there may be some association between streptococcal diseases of the udder and outbreaks of sore throat.

Trask collected fifty-one scarlet fever epidemics reported as spread by milk. Twenty-five of these occurred in the United States, twenty-six in Great Britain. In thirty-five of the epidemics a case of scarlet fever was found at the producing farm, the distributing dairy, or the milkshop, at such a time as to have been a possible source of infection. In three of the outbreaks bottles returned from infected households and refilled without previous sterilization were given as the source of infection. In three of the outbreaks scarlet fever persons handled the milk or milk utensils. In twelve of the outbreaks the cows were milked by persons having scarlet fever. One epidemic was caused by the same person nursing the sick and handling the milk. Two of the outbreaks were attributed to disease of the cow.

Milk-borne outbreaks of scarlet fever are sometimes unusually extensive. A good illustration is the epidemic which occurred in Boston in the spring of 1910 as the result of infected milk.

The Boston epidemic occurred during April and May. A

total of 842 cases was reported from Boston and the surrounding towns of Chelsea, Winthrop, Cambridge, Somerville, Milton, and Everett. Investigations showed that most of the cases occurred on the route of one of the large milk contractors. Of the 409 cases in Boston, 286, or nearly 70 per cent, were on the route of this dealer, while 123, or 30 per cent, used other milk. Of the 155 cases that occurred in Cambridge, 126, or over 80 per cent, were on the route of the same dealer. About the same proportion of the cases in the other cities used the milk of this dealer.

The epidemic cropped out suddenly April 25, and the outbreak ceased May 7. The epidemic reached its highest mark on April 29, on which day 123 new cases were reported. The indications were plain that the outbreak was the result of more than a single infection. The milk was pasteurized on April 27, and three days following there was a notable and sharp decline in the number of cases. The actual source of the infection could not be traced, and it is supposed that it consisted of a missed case on one of the 250 dairy farms from which the dealer obtained this particular supply of milk.

Diphtheria

The fact that diphtheria may be spread by milk was not definitely recognized until very recently. The first epidemics apparently due to milk were reported in 1877 and 1878 in England.

The bacillus of diphtheria will grow and proliferate in milk at a prodigious rate. Like the typhoid organism it does not appreciably change the appearance, taste, or color of the milk.

In almost all the epidemics that have been carefully studied, the diphtheria bacilli gained entrance to the milk from the secretions of the nose and throat of a person having diphtheria or from a diphtheria bacillus carrier. Klein and other English investigators believed that milk may be

infected with diphtheria bacilli from eruptive diseases of the udder. It is quite possible that open wounds upon cows may become infected with the diphtheria micro-organism and thus contaminate the milk.

Dean and Todd isolated the diphtheria bacillus from ulcers of the teats and udders of a cow which presumably became infected from the throat of the milker, who was shown to have diphtheria. Such instances are rare. When diphtheria is found in milk it is practically always of human origin.

The diphtheria bacillus has actually been isolated from market milk by Bowhill, Eyre, Klein, and Dean and Todd.

Bacillus-carrying is exceedingly common in diphtheria. About one per cent of the population at large have micro-organisms resembling the diphtheria bacillus in their throats. Convalescents from diphtheria frequently continue to carry the diphtheria bacillus in the secretions of the nose and throat for months after the attack of the disease. Persons who come in contact with diphtheria patients are very apt to become bacillus carriers without actually having the disease. Further, many cases of diphtheria are exceedingly mild and resemble a transient sore throat, so that they escape detection unless a careful bacteriological examination is made. It is these mild cases and the bacillus carriers that have been responsible for the great majority of instances in which milk has spread diphtheria. Bacillus-carrying in diphtheria is, then, even more common and quite as insidious as it is in typhoid fever. Even certified milk has on one occasion become contaminated in this way.

Trask collected twenty-three epidemics of diphtheria reported as spread by milk between the years 1895 and 1909. Fifteen of these occurred in the United States and eight in Great Britain. In eighteen of these epidemics, cases of the disease were traced to the dairy farm or the distributing dairy or milkshop. In four of the epidemics dis-

eased persons milked the cows, in one of the epidemics the same person nursed the sick and handled the milk; and two of the outbreaks were supposed to be due to disease of the cows. Diphtheria bacilli were actually isolated from the suspected milk in two of the epidemics.

One of these diphtheria epidemics is especially interesting and is cited as an example of a milk-borne outbreak. This occurred in Dorchester, Milton, and Hyde Park, suburban towns near Boston, and is fully reported in the "Monthly Bulletin" of the State Board of Health of Massachusetts for May, 1907 (vol. II, no. 5, p. 117). There were a total of seventy-two cases in this outbreak, eighteen of which occurred in Milton, thirty-six in Dorchester, and eighteen in Hyde Park. All the cases occurred in the week of April 12 to 19, in the year 1907. All the cases in these three towns were traced to two dairies, which we will call A and B. Both these dairies obtained some milk from a dairy farm where it was discovered that a child had been attacked with the disease on April 11. In this case the cooler in which the milk was mixed was washed in the house by the person who had the care of the sick child. Prompt action on the part of the local authorities in excluding the sale of milk produced from this dairy farm brought the outbreak to an immediate close. It is interesting to note that the proprietor of the dairy farm himself came down with the disease after the outbreak had nearly subsided, and that dairyman A's son, who drank the infected milk, was one of the earliest victims.

As a rule, outbreaks of diphtheria due to milk are less frequent and less extensive than outbreaks of typhoid fever or scarlet fever.

"*Septic sore throat*" — *Streptococcus tonsillitis*

A disease variously known as "septic sore throat," "streptococcus tonsillitis," "angina," "sore throat," etc., is sometimes conveyed by milk. Outbreaks of sore throat

due to infected milk have not been recognized in this country until recently. In May, 1911, an outbreak involving several thousand persons occurred in Boston. Since then similar outbreaks have occurred in Baltimore, Concord, New Hampshire, Chicago, and other places throughout the country. The disease is evidently spreading. In March, 1908, a similar outbreak occurred in Christiania, Norway.

"Septic sore throat" due to infected milk is well known in Great Britain. Swithinbank and Newmann (1903) even go so far as to say, "It is safe to assume that a year never goes by in which there are not outbreaks of sore throat or tonsillitis due to milk or cream." Outbreaks belonging to the tonsillitis or quinsy type (septic sore throat), more or less paralleling the Massachusetts epidemic, were reported at Aberdeen and at Rugby School in 1881, at Dover in 1884, at Edinburgh in 1888, at Rothesay in 1890, at Hackney in 1900, at Lincoln and Bedford in 1902, at Woking in 1903, at Glasgow and Paisley in 1904, and at Colchester in 1905. The evidence that the disease was spread by milk is quite convincing in almost all these cases, and in many of them the character of the disease, called by the English sanitarians "septic sore throat," was exactly as noted in our country over the past year. The appearance of the throat, the relapses and enlarged regional glands, the occurrence of complications such as rheumatism, erysipelas, and septic infections, are all described, as well as the heavy incidence among females.

These infections appear to be due to a streptococcus, and it is probable that the pathogenic streptococci responsible for the disease get into the milk from human sources. It is possible, however, that cases of sore throat are sometimes caused by contamination of the milk not from a human source, but from streptococci eliminated by diseased udders.

The outbreaks of sore throat due to milk are charac-

terized by all the serious complications which are associated with streptococci, such as erysipelas, rheumatism, and peritonitis. Relapses are common, the glands of the neck become very large and tender, and sometimes suppurate.

The outbreak of septic sore throat in Boston. In May, 1911, an extensive and serious outbreak of "tonsillitis" occurred in Boston and in the neighboring town of Brookline and city of Cambridge. There were, all told, over two thousand cases, with about forty-eight deaths. The infection was believed to be conveyed in the milk from the Deerfoot Farms at Southboro. This was not only the most widespread and serious but the first epidemic of this kind traced to milk in this country. It corresponds in all essential particulars to the outbreaks of septic sore throat which have frequently been reported as occurring in England. The Boston-Cambridge-Brookline epidemic presents interesting details, some of which are here given.

Tonsillitis not being a reportable disease, accurate vital statistics of the epidemic are not at hand. The facts as here given are taken from the epidemiological studies of Winslow, and also from the special studies and records of the health offices of the three affected towns.

Two forms of sore throat occurred at the time. The clinical and epidemiological features of these two forms of sore throat give the picture of two separate and distinct diseases; the one ordinarily diagnosed *tonsillitis* was benign, directly contagious, and presented no unusual features from the usual sore throat more or less prevalent in almost all large communities; the other disease, which we will call *septic sore throat*, was malignant, not readily communicable from person to person, and presented special clinical features. The inflammation and swelling of the lymph structures of the throat and of the mucous membranes were more severe than ordinarily. Edema was a feature, and many of the cases presented pseudomembranous formation and

other indications of a virulent infection. The Klebs-Löffler bacillus was absent. Cultures showed almost the constant presence of streptococci, also staphylococci and pneumococci. In addition to the difficulty in swallowing and other local symptoms, the patients had a sharp febrile reaction, prostration, and sometimes delirium. The duration of the disease was prolonged and complications occurred in about one quarter of the cases. These consisted mostly of enlarged regional lymphnodes which frequently suppurated, abscesses, arthritis, endocarditis, peritonitis, erysipelas, pneumonia, and other *sequelæ* indicating the invasion of the blood with a virulent streptoccus.

The unusual clinical features of this epidemic disease were its extraordinary virulence, the comparative immunity of children, the high mortality among the aged and infirm.

The disease in question, so far as any abnormal epidemic prevalence was concerned, was confined to two definite foci centring respectively (1) about Boston on the seacoast and (2) about Marlboro, twenty-five miles to the westward. The Boston epidemic affected the Back Bay principally, the neighboring town of Brookline and the adjoining city of Cambridge.

The outbreak which centred about Marlboro preceded the Boston outbreak by a month or six weeks. There were at least 392 cases in the towns of Hudson, Marlboro, and Southboro. These towns did not suffer with a sudden explosive outbreak of the disease such as occurred in Boston. Instead, the disease simply prevailed in prosodemic fashion with fairly even distribution over a period of about five weeks. In addition to this prosodemic prevalence, Marlboro and Southboro had a superadded outbreak, simultaneous with that in Boston, during the second and third weeks of May, including an epidemic of sixty-four cases in two boys' boarding-schools supplied with Deerfoot milk.

The Deerfoot Farms receive their milk supplies from

dairy farms located in Southboro and Northboro, where the disease prevailed. While no record has been obtained of any well-defined cases of tonsillitis in direct contact with the milk, cases are known to have occurred at the proper time in a family on one of the farms and in a family of employees at the Deerfoot Dairy. It is presumed, then, that the actual infection got into the milk from a bacillus carrier or a mild or missed case. A careful veterinary examination failed to disclose any disease of any of the cows furnishing the milk in question sufficient to account for the infection.

The mixed milk at the Southboro dairy and the separate milk from all the individual dairies are examined by Professor S. C. Prescott, who gives the following records for the month of May: —

BACTERIA PER CUBIC CENTIMETRE IN SOUTHBORO BOTTLED MILK

Date	Number in each of several samples		
May 1	200,000	120,000	140,000
May 3	23,000	75,000	250,000
May 5	30,000	15,000	10,000
May 8	35,000		
May 10	170,000	200,000	80,000
May 15	45,000	70,000	75,000
May 18	100,000	150,000	60,000
May 26	150,000	150,000	130,000
May 26	45,000	300,000	200,000
May 29	85,000	95,000	45,000

The above table gives the counts obtained from samples of the mixed milk at the Southboro dairy, and represents counts made after twenty-four hours at 37° C. The samples of milk were also examined, after centrifuging, for leucocytes and streptococci, with no excess of either in any sample.

The disease jumped from the focus around Southboro to Boston by express, and the outbreak was rather strictly

limited to the distribution of the milk. Approximately eight hundred cases occurred in the Back Bay district, over one thousand cases occurred in Cambridge, and at least two hundred and sixty-five in Brookline, making a total of over two thousand cases. The disease began about May 8, reached its maximum May 14, and suddenly ceased May 19 to 22. Twenty-two per cent of the households affected had three cases or more. Females suffered twice as much as males, and adults more in proportion than children. Two-thirds of the fatalities occurred at ages above fifty-five and one third at ages above seventy-five.

The distribution of the epidemic exactly coincided with that of one of the two main milk supplies of the Deerfoot Company. It affected the particular districts in Boston, Brookline, and Cambridge where this milk was used, and it broke out simultaneously in Marlboro and Southboro, the only other towns to which it was distributed. Eighty-five per cent of the cases in Boston and Cambridge were upon the delivery list of the dairy, while an additional eight per cent were stated by physicians to have used the milk, though not listed as subscribers. In sharp contrast to this, the Deerfoot supply makes up only one per cent of the Boston and two per cent of the Cambridge total. In Brookline sixty-five per cent of the cases were on the Deerfoot list and eight per cent more stated to have used the milk. In this town the Deerfoot supply constitutes about seven per cent of the total. A study of the delivery lists for Brookline and Cambridge showed that in each case about one family out of every four supplied had been infected.

One of the features of special interest concerning this outbreak was that the Deerfoot milk has always been a particularly clean, fresh, and satisfactory supply. It is obtained from tuberculin-tested cows, under constant veterinary supervision, and the milk itself is subjected to daily chemical and bacteriological tests. The milk is bottled at the dairy, the bottles are sterilized, and all reason-

able and many extra precautions are taken to insure its cleanliness and purity. For twenty-eight years not a breath of suspicion was attached to this milk until this catastrophe occurred. It emphasizes the lesson that raw milk is apt to be dangerous milk, and our only protection against these particular dangers is through pasteurization.

Other outbreaks of septic sore throat. As illustrations of such outbreaks of sore throat, the three following cases are taken from among those summarized by Swithinbank and Newman.[1]

In Anglesey, in 1897, fifteen people who took milk of one dairy became affected at about the same time with sore throat. Several persons in the affected families who consumed milk from the same source, but in a boiled state, escaped the sore throat, the chief evidence of which was tonsillitis. The bacteriological examination of the milk revealed the presence of *Streptococcus pyogenes* and *Staphylococcus pyogenes*, but no *Bacterium diphtheriæ*. Bacteriological examination of the patients' throats yielded precisely similar results.

In May, 1902, an outbreak occurred in Lincoln, affecting a large number of persons. Dr. Brook had seventy-five cases in his own practice. The chief symptoms were erythema of the face, and sore throat. In many cases a drab-colored fur covered the tonsils. A roseolous, papular eruption, in some cases appearing to be urticarial, occurred in two thirds of the cases. There was no marked fever, except in cases having complications. The pulse rate was not increased, and no albuminuria occurred. The onset was sudden, and in no case out of seventy-five investigated by Dr. Brook was infection communicated to others by contact. Nearly all of the patients were adults, and well advanced in years. The complication most commonly met with was swelling and tenderness of the cervical glands. With one doubtful exception, all the patients had had milk from the same dairy. Boiling the milk appeared to prevent persons from taking the complaint. The poison seemed to be present particularly in the cream. The differences between the disease and scarlet fever were very marked.

A sudden outbreak of a severe form of "septic sore throat"

[1] *Bacteriology of Milk.*

occurred at Bedford at the end of June, 1902. On 27th June, the first case occurred; on 29th June, four cases occurred; 30th June, fifteen cases occurred; 1st July, thirteen cases; 2d July, three cases; 3d July, two cases; and 4th July to 8th July, four cases,—making a total of forty-two cases in twenty-two families. The symptoms included redness, swelling of the throat, fauces, palate, and uvula, with numerous spots, patches of exudation, and in some cases ulcers. The general symptoms consisted of severe headaches, giddiness, backache, and pains in the limbs, very much like an attack of influenza. The temperature was about 102° to 103° F., but in a few cases was higher. In some cases there was gastric and intestinal disturbance. Great weakness was also present. In every case the milk supply was obtained from the same dairy. On Sunday, 30th June, many persons consumed cream with fruit, and these included nearly all the worst cases. In some families children who drank boiled milk escaped, whilst parents who consumed unboiled milk or cream were attacked. One man took cream in the form of ice cream, and had a severe attack.[1]

Further illustrations of outbreaks of septic sore throat due to milk are given in the recent volume upon "Milk and the Public Health," by William G. Savage.

Milk sickness

Milk sickness is a peculiar disease also known as the "sloes" or "trembles." It was once very prevalent throughout the central part of the United States, and was one of the dangers our pioneering forefathers had to contend with. In some localities the disease was so prevalent and fatal that whole communities migrated from the milk-sick sections to parts where the disease did not occur.

We are told by Colonel Henry Watterson that Nancy Hanks, the mother of Abraham Lincoln, died from this disease in 1818 after an illness of a week. In the words of Colonel Watterson, "the dreaded milk sickness stalked abroad smiting equally human beings and cattle." Trem-

[1] C. C. Jensen, *Essentials of Milk Hygiene.* Translated by L. Pearson. Philadelphia and London: J. B. Lippincott Co., 1907.

bles in animals is now almost as rare as milk sickness in man. As the forests are cleared and pastures fenced, the disease becomes less frequent. It is still met with in the valley of the Pecos River, New Mexico, in Tennessee, North Carolina, and other thinly settled sections. Jordan and Harris have found a bacillus associated with the disease which they have called the *Bacillus lactis morbi.*

Milk sickness is an acute, non-febrile disease due to the ingestion of milk or the flesh of animals suffering from a disease known as "trembles." The affection is characterized by great depression, persistent vomiting, obstinate constipation, and a high mortality. The virus may also be taken into the system through butter, fresh cheese, and other milk products. Heat apparently has very little effect upon it, and there is no known cure or prevention except the elimination of the disease in cattle, which fortunately is rapidly taking place.

Foot-and-mouth disease

Foot-and-mouth disease is primarily a disease of cattle and secondarily of man. It is an exceedingly interesting affection from many standpoints. It was the first virus proven to be ultramicroscopic in size. The micro-organism is so small that it cannot be seen with the highest powers of the microscope and will pass through pores of the finest porcelain filter. This was proven by the experiments of Löffler and Frösch in 1898.

The foot-and-mouth disease, also known as "aphtha fever," "epizoötic aphtha," and "eczema contagiosa," is one of the most highly infectious diseases of cattle and other domestic animals. The characteristic feature of the disease is an eruption of vesicles which break out on the mucous membrane of the mouth, and also on the skin between the toes and above the hoofs. The vesicles rupture, forming erosions and ulcerations. When this happens in the mouth there is salivation, tenderness of the affected parts, loss of

appetite; at the same time there is lameness, emaciation, and diminution in the quantity of milk secreted.

The disease is remarkable in that the mortality is very light (only about one per cent of the animals affected die). The economic losses, however, are very great, for an animal, after passing through an attack of foot-and-mouth disease, may be practically worthless as a milch cow and will only bring a very greatly reduced price at the slaughter-house.

The milk becomes thin, bluish, and poor in fat. In the early stages or in a mild attack of the disease, the milk may present only a few abnormal characteristics, such as a fall in specific gravity to 1.023 or 1.025 and a reduction in the quantity of milk sugar and casein. When the disease is fully developed, about the third day, the milk invariably contains inflammatory products of very pronounced character and the quantity of milk secreted is greatly reduced. Cows affected with the malignant form of the disease lose practically all their milk: even when the disease is mild in character the decrease will be from one third to one half of the usual yield. If the udder becomes involved, the milk has a slimy consistence and is yellowish and viscous like colostrum. It frequently contains coagulated fibrin and blood, so that a considerable sediment forms upon standing, while the layer of cream which rises is thin and of a dirty color. The milk may even have a bad odor and a repulsive, rancid taste.

The disease is transmissible to man through ingestion of raw milk, buttermilk, butter, cheese, or whey from diseased animals. Occasionally the disease is transmitted directly from the infected secretions. Children are not infrequently infected by drinking unboiled milk during the periods in which the disease is prevalent in the neighborhood.

The symptoms in children resemble those in the cow very closely. There is fever, sometimes vomiting, painful

swallowing, heat and dryness of the mouth, followed by the eruption of vesicles in the mouth and very rarely by similar blisters on the fingers. The vesicles appear on the lips, gums, cheek, and edge of the tongue, and are about the size of a pea. They soon rupture, leaving a small erosion, which is soon covered by a thin crust under which the new formation of epithelium proceeds rapidly. The disease is mild in children, and therefore is frequently not seen by physicians, and is commonly regarded by the mother as a form of "fever blister," "thrush," or one of the minor affections of the mouth.

The virus is readily killed by heat: it is destroyed with certainty at a temperature of 60° for twenty minutes. Pasteurized milk, therefore, will not convey this infection.

There have been five outbreaks of foot-and-mouth disease in this country. Each time the epidemic was controlled by energetic measures, such as quarantining the infected areas, the destruction of the diseased cattle, and general disinfection. The disease, however, prevails to a very wide extent in many parts of Europe and Asia.

Mammitis, mastitis, or garget

This disease, or rather series of diseases of the udder, is by far the most frequent affection of milch cows. It consists of an inflammatory condition of the mammary gland. The tender mammary gland is especially liable to injury and is particularly subject to inflammations as a result of the invasion of various germs, especially streptococci and staphylococci. The list of micro-organisms found associated with garget is a very long one.

Frequently only one quarter of the udder is affected, although the whole udder may, at times, be involved. The affected quarter is greatly swollen and more or less painful in the early stages. The milk at first appears normal, but soon changes its character, becoming watery, light brown

in color, and in some cases appears tenacious, slimy, ropy, and contains flocculi and pus cells. The milk from such an udder is objectionable from an æsthetic standpoint, and is also liable to give rise to gastro-intestinal disorders, especially in children. The existence of a gargety cow in a herd may be suspected if the milk contains many pus cells and unusual numbers of streptococci.

The milk regulations of practically every civilized country in the world forbid the use of the milk obtained from a cow having any inflammatory condition of the udder. Such regulations are wise, and inspectors as well as dairymen should keep a careful watch for this affection.

Malta fever

Malta fever is a general infection not unlike other specific diseases, such as typhoid fever. It is caused by the *Micrococcus melitensis*, discovered by Bruce in 1887 during the earlier days of bacteriology. The disease is remarkable in that it seldom leads directly to death, but is a long-drawn-out affliction. It is not unusual for a patient to suffer from malta fever from six months to two years, with rheumatic or neuralgic pains, sometimes swelling of the joints, and low fever, profuse perspiration, constipation, and frequent relapses. It prevails especially about the Mediterranean basin. Authentic cases have recently been found in Texas along the Rio Grande.

Malta fever interests us especially because it is usually transmitted through goat's milk. It may also be transmitted in other ways, — for example, the virus may be taken into the system through wounds, or by food and drink, other than milk.

Goats are susceptible to malta fever and continue to discharge the virus in the milk for a long time after they have recovered from the disease. People who drink such milk in its raw state are very apt to contract the disease. For this important fact we are indebted to the reports of the British

commission who investigated this fever between the years 1905 and 1907.

An interesting outbreak of malta fever occurred upon the steamship Joshua Nicholson. This outbreak is instructive in showing the relation between goat's milk and malta fever in man. Sixty-one milch goats, all healthy in appearance and good milkers, many of them in fact being prize animals, were taken on board the steamer Joshua Nicholson August 19, 1905, at Malta for passage to the United States *via* Antwerp. Of twenty-three men on board the steamer who drank the goat's milk on one or more occasions, nine suffered from malta fever; no data could be obtained of thirteen; one escaped the disease. The *Micrococcus melitensis* was isolated in pure culture from the milk of several of the goats.

Major Horrocks shows that there is a direct relation between the number of goats in Gibraltar and the number of cases of malta fever. With the reduction in the number of goats, there was also a decrease in the number of cases, so that when the number of goats had decreased to about two hundred in 1905, malta fever had practically disappeared.

The virus of malta fever in goat's milk is readily destroyed by heat, so that there is no danger from pasteurized or boiled goat's milk.

There are a number of other diseases and conditions of the cow which render the milk either undesirable or unsafe for human consumption. Among these may be mentioned actinomycosis, bothryomycosis, anthrax, cow-pox, rabies, gastro-enteritis, septic or febrile conditions, etc. In some of these conditions the milk itself does not contain the active principle of the disease; in others it may do so. In some of the conditions mentioned, the milk may be unnatural in color, appearance, or taste, frequently contains pus or blood, and is always highly undesirable.

CHAPTER V

CLEAN MILK

CLEANLINESS is the keynote to the whole situation. Clean milk is the milk in the cocoanut. In fact, that magic word "cleanliness" underlies all sanitation and hygiene.

Cleanliness has a different meaning to-day from what it had fifty years or more ago. Then we only knew of æsthetic cleanliness: now a thing is not clean unless it is biologically clean. An object may look clean, but nevertheless be infected. On the other hand, an object may look dirty, but be biologically clean. However, clean-looking things are apt to be safe things, and clean methods are the only safe methods. The old-fashioned housekeeper who kept her pots and pans shining and her kitchen cleaner than her parlor is a model of the type of cleanliness needed in good dairy practice. Cleanliness means not only the absence of dirt and infection, but it also means the absence of flies, roaches, ants, rats, mice, and other vermin.

A clean stable, a clean dairy, a clean milk room has no odor. An unpleasant, disagreeable, or sourish milk odor is a sure sign of lack of cleanliness. This simple telltale is one of the best evidences we have of the efficiency of the methods used. Milk is so sticky and greasy, and adheres so tenaciously to surfaces that ordinary methods of cleanliness will not suffice. It requires plenty of elbow-grease to keep things clean about a dairy or dairy farm. All apparatus must be taken apart daily, thoroughly scrubbed, cleansed, and scalded. Scrupulous cleanliness applies to floors and all surfaces, to milk pails and all containers, to milk heaters and all apparatus. All piping should be freely accessible and contain no rough surfaces or places where milk will

collect. Corners, cracks, crevices, and irregular surfaces will sooner or later gather a decomposing film of organic matter. Cleanliness of person is even more important than cleanliness of things.

Clean milk pays because it keeps longer and because it is better and safer than dirty milk. Clean milk costs more to produce, yet the consumer hesitates to pay a fair price. At present, clean milk at a fair price is almost a drug on the market.

Clean milk that has been cooled as soon as drawn and kept at a low temperature will change little in three or even five or more days, and may therefore be better than fresher milk which has been carelessly handled. Thus, in a sanitary sense, it is possible for a clean milk five days old to be better than a dirty milk one day old.

At the Paris Exposition in 1900, as pointed out by Spargo, one of the most significant of all the food exhibits was that of the American dairy products, particularly of milk and cream. European authorities were astounded. They simply could not understand how it was possible for milk and cream, raw, in its natural state, without preservatives of any kind, to be shipped all the way from New York, New Jersey, or Illinois to France, and be in good condition upon its arrival and remain pure and sweet. The French agriculturists were dumbfounded, for they could not bring their milk a distance of little more than one hundred miles and have it in good condition for more than forty-eight hours under the most favorable conditions. Major Alvord, who was in charge of the exhibit, found it no easy matter to convince the milk experts on the jury that the milk was in its natural state, uncooked and undoctored. Nothing but "cold and cleanliness" were used to attain such wonderful results.[1]

If a dairyman has an inborn capacity or instinct to be clean, a little instruction will enable him to do satisfactory

[1] Spargo, *The Common Sense of the Milk Question.*

IT IS DIFFICULT TO OBTAIN CLEAN MILK UNDER SUCH CONDITIONS

A MODEST BUT CLEAN COW BARN, IN WHICH MILK THAT WILL SATISFY SANITARY REQUIREMENT MAY BE OBTAINED WITH GOOD DAIRY METHODS

A NEAT, CLEAN, INEXPENSIVE COW BARN

work, but if he is lacking in this quality it is very difficult to change his methods by any amount of instruction and public regulation. The contamination that enters milk because of this lack of the sense of common cleanliness may be serious.

Unfortunately, clean milk is not necessarily safe milk, for even certified milk may, at times, contain invisible foes such as the pathogenic bacteria; however, it is perfectly evident that harmful bacteria are much less apt to be contained in clean milk than in dirty milk. Reference has already been made to the fact that a certain dairyman in Boston produced an exceptionally clean and satisfactory milk for twenty-eight years, when one day last spring it became contaminated with the discharges from a case of sore throat, with dire results. Other instances in which clean milk has become carrier of infection are not uncommon — perhaps for the reason that such milk is usually consumed raw.

The dangers from dirty milk have been considered, and it now seems unnecessary to emphasize the importance of clean milk, especially for infant feeding. It is conservatively estimated that if all the babies in New York could have clean milk, it would probably save about six hundred little lives a year. There are many philanthropic associations which have for their object the production of clean milk for babies. Among these may be noted the Straus milk depots in New York City and elsewhere, the *gouttes de lait* in France, the Milk and Baby Hygiene Association in Boston. Municipal depots have been established in Rochester under Dr. Goler's leadership. Belgium and also France have municipal infants' milk depots subsidized by public funds.

Fresh milk

It must be plain by this time to those who have followed thus far that milk should be as fresh as it is practicable to

obtain it. Milk does not keep well. It is, in fact, the most readily decomposable of all our foods. Deterioration progresses from the moment it is drawn from the udder; sometimes before. Even when kept very cold, milk undergoes marked changes and finally spoils.

During the first six or eight hours milk contains a natural preservative which keeps down the bacteria and delays decomposition. This is known as the germicidal property of milk. Hence, if the milk delivered to the household could be twelve or even twenty-four hours old, a great gain would be had and many of the troubles of the producer and complaints of the consumer would vanish. The health officer would also have less to do.

I have all along emphasized the importance and desirability of fresh milk and believe that a special effort should be made to have milk supplied to metropolitan centres not over twenty-four hours old. At present the bulk of the market milk of large cities is at least forty-eight hours old, — sometimes older. Stale milk is more than undesirable; it may be dangerous. Health officers should prohibit the sale of stale milk. This, however, is not such an easy task, for it is not possible to determine the age of milk by any known test. But the facts may be learned from an intelligent system of inspection.

In times of strikes, of local milk famines, and for other reasons, milk contractors sometimes get a supply from unusually distant points. Such milk may be four or six days old when delivered to the consumer. To keep that long, it must be pasteurized twice. This should never be allowed except in a real emergency, and then with full and frank admission to the public. It pays to take the public into the confidence of the farmer and contractor and the health officer.

Smaller towns have a great advantage in that they are able to obtain a fresh milk supply within wagon-haul at least once, and in special cases twice, a day. The problem

for the smaller town is, therefore, somewhat simpler than for the large city.

Coöperation between the farmer, the railroad, and the middleman would do much towards bringing a fresher supply of milk into the city. The milk trains should be fast express trains run on a careful schedule arranged to prevent delays at the intermediate stations and the terminals.

One of the reasons that the milk supply of cities is older than it should be is the demand of the householder to have the milk early in the morning before breakfast. This is a survival of the days when the morning's milk was brought fresh to town by the farmer's wagon. If the householder had better refrigerating facilities for preserving the milk, and were willing to receive it during the daytime, he could, on the average, obtain milk approximately twenty-four hours earlier than he now receives it. On the other hand, it is an evident advantage for the householder to receive the daily supply in the morning for the use of the day — and keep none of it overnight. The facilities for refrigeration in the dairy are vastly superior to the average family ice-box.

Dr. North's plan

About two years ago the New York Milk Committee organized the Dairy Demonstration Company. A dairy was purchased and rehabilitated at Homer, New York; it is now sending six thousand quarts of clean milk to the city every day. The object of the Dairy Demonstration Company was to demonstrate the fact that a clean and satisfactory milk may be produced with little increase in expense. This they have succeeded in doing. The methods by which this has been accomplished are exceedingly simple. The essential features are the following: —

1. First of all, the farmer is paid for his time and trouble in complying with the sanitary requirements. He is given one half a cent a quart more for his milk to compensate

him for the tuberculin testing and the losses incident thereto. He is given one fourth of a cent a quart more for his milk provided he keeps the bacteria below 10,000 per cubic centimetre. He is given one fourth of a cent for each point (0.1 per cent) of butter-fat in excess of 3.5 per cent. In other words, he is paid a premium for sanitary excellence and nutritive quality. The milk might be called, with propriety, "premium milk." The farmers receive, on the average, about one cent a quart in premiums. In addition to the premium stated, the farmers also receive prizes for the lowest bacterial count and receive other encouragements to excel. Those who work in the creamery are also given premiums, provided no additional bacteria are added to the milk as it passes through the creamery.

2. Emphasis is placed upon good dairy methods rather than upon equipment. The essential feature in the methods in producing this milk consists in cleaning and sterilizing the pails and cans at the dairy. The farmer takes away these prepared utensils when he delivers his milk in the morning. There are at present thirty-five dairy farms in this coöperation scheme. The simple device of cleaning and sterilizing the pails and cans at the dairy at once eliminates thirty-five dairy wells, does away with the imperfect cleansing and sterilizing as it would be carried out by thirty-five individual farmers, and eliminates thirty-five kitchens and households where milk pails and cans are ordinarily washed. The pail has a small opening and is covered, which, in itself, excludes three fourths of the dirt. The farmers soon find that it is to their advantage to wipe the udders and teats, before milking, with a damp cloth in order to keep their bacterial counts down.

3. The milk is brought promptly to the dairy, where it is handled with care and expedition. It is strained, cooled at once, then filled into clean and sterile bottles. These are iced and shipped to town in refrigerator cars. Samples are taken daily from each farmer for bacteriological and

chemical analyses. A sample is taken both of the morning and evening milkings. As the farmers in this section live near by the dairy, they may bring their morning's milk within a few hours after it is obtained. The morning's milk, therefore, need not be iced by the farmer. This is done for him at the dairy. The evening's milk, however, must be cooled and iced in order to keep the bacteria from multiplying.

4. Another essential feature of Dr. North's plan consists in treating the farmer fairly and receiving a square deal in return. The farmers about Homer first went into this new arrangement with skepticism and doubt. Now mutual confidence has been established, with the result that the farmer finds joy in his work and is willing to adopt suggestions from his sanitary advisers.

Certified milk

Certified milk is the very best, the very freshest, the very cleanest, the very purest, and the very safest raw milk that it is possible to produce. It is milk of uniform composition and of highest quality, obtained by cleanly methods from healthy cows under special sanitary precautions prescribed by a medical milk commission. Certified milk represents one of those high ideals which at first seems visionary and unattainable, but is, in reality, an accomplished fact.

The production of certified milk in many instances is an example of the saying that peace has its heroes and victories no less than war. It does not appear to be quite so valiant a deed to capture the stronghold of prejudice, in order to prevent sickness and save the lives of babies, as it does to charge up a hill against hostile guns. The introduction of certified milk into a community is a real struggle which requires patience, capital, pluck, and determination. The people become slowly educated to its value and importance. There are two classes in a community, namely,

the medical profession and the well-to-do citizen, whom we would expect would eagerly favor and foster such a real step in the march of progress. Unfortunately, however, the medical profession does not always see its responsibilities in its broadest light; further, the patrons of certified milk are not especially the rich people, who perhaps are rich partly because they do not buy certified milk.

Pearson states: —

> Certified milk producers are pioneers. . . . Producers of certified milk deserve much credit for what they have done in bringing about better methods of milk production. They deserve credit for what they have done in educating the public to appreciate the value of clean, wholesome milk; it is largely due to their efforts that we find a more general demand for milk of better sanitary quality accompanied by a willingness to pay a fair price for such milk. This is noticeable in the slightly increasing sale of certified milk; it is still more noticeable in connection with milk being sold on the general market. Dairymen who produce milk of fairly good sanitary condition are beginning to receive a little better price for such milk than those who give no special attention to cleanliness.

The name "certified milk" lacks the charm and attractiveness that favor popularity. The term is technical and incomplete, for it requires an explanation in order that persons may know it is milk produced under very special conditions which are certified to by a medical milk commission. The average man does not know who certifies it or how. Even physicians do not always have a clear understanding of the term "certified milk." It should be remembered that the movement is young. The first certified milk was produced but eighteen years ago. The movement is growing, not only in our own country, but is extending abroad. Other names have been suggested to take the place of certified milk, such as "guaranteed milk," "baby's milk," etc. In fact, in a few instances milk not certified, but sold under special names, such as Walker-Gordon laboratories, guar-

anteed milk, babies' milk, etc., is of equally high grade as the orthodox certified quality. The term "certified" is as good as any other, and has now taken such a hold that it would be unfortunate to make any attempt to change it.

There is a certain lack of coöperation and need of reciprocity on the part of the certified milk movement. Except for a general feeling of accord and a desire on the part of each medical milk commission to produce the highest grade of milk, there is no special cohesion between the various milk commissions and certified milk producers. The American Association of Medical Milk Commissions and the Certified Milk Producers' Association of America are voluntary organizations which have done much to cement closer association and to provide uniformity of standards and methods. As an instance showing the lack of coöperation and need of reciprocity is the fact that milk produced by the Massachusetts Agricultural College of Amherst is certified by the Medical Milk Commission of Suffolk County, but is not recognized as certified milk by the neighboring towns of Cambridge and Malden. Numerous similar instances could be cited.

Not all milk sold as certified milk is really certified. As an example I will cite an episode which occurred in Rhode Island. In the city of Providence a certified milk was placed upon the market. After a time, however, the parties who produced it failed to make good. Consequently the certificate was stopped. The dealer, however, continued to advertise his milk as certified, and finally obtained from the legislature a charter which gave him the exclusive privilege of using the term "certified" in connection with the sale of milk. Meanwhile the secretary of the State Board of Health of Rhode Island informs me that this milk "has actually been below the average of many of our better class of producers." Such a serious menace to the certified milk movement deserves correc-

tion, and no stone should be left unturned until the word "certified" is as clean as the product itself.

Historical. In the year 1893, after several years of labor, Dr. Henry L. Coit, of Newark, induced the State Medical Society of New Jersey to appoint the Essex County Medical Milk Commission. Some months later a dairyman by the name of Stephen Francisco signed a contract with this commission to produce milk under its supervision, and thus the first certified dairy plant was established. The term "certified" was coined by Dr. Coit and copyrighted by Mr. Francisco, in order to protect it against abuse and with the understanding that any properly qualified milk commission should have the right to its use. The term "certified milk," therefore, simply means that the milk is certified as to quality and wholesomeness by a medical milk commission.

The standards of the first medical milk commission were high, but have since gradually been raised and the supervision over the production and handling of the milk has been made more definite. The idea took hold slowly, but surely, and in the fourteen years following 1893, largely through the assistance of Dr. Coit, some twelve other milk commissions were organized in various cities throughout the country. Upon the invitation of Dr. Geier, of Cincinnati, representatives from these twelve commissions met June 3, 1907, at Atlantic City and organized the American Association of Medical Milk Commissions. After that time a marked impetus was given to the certified milk movement, so that at the present writing there are some sixty medical milk commissions prepared to certify milk in the United States.

The purpose of the American Association of Medical Milk Commissions is to federate and bring into one compact association the medical milk commissions of the United States, to exchange views, to adopt uniform methods of procedure, to fix chemical and bacteriological stand-

ards, to determine the scope of veterinary inspection, and finally to foster and encourage the establishment of medical milk commissions in other cities.

The producers soon found it to their advantage to organize a national association, the Certified Milk Producers' Association of America, which had its first meeting in 1908. Cordial coöperation between the two associations is being fostered.

The medical milk commission. The medical milk commission is usually appointed by the county medical society, which is the unit of the organized medical profession as represented by the American Medical Association. In fact, the law of New York, as well as of other cities and states, recognizes only those milk commissions appointed by county medical societies, organized under and chartered by the medical society of the state. In a few instances, commissions are in existence which have been self-appointed and which are doing excellent work. In the interest of uniformity and harmony it is advisable that all medical milk commissions should receive their commission from the county medical society. The personnel of a medical milk commission should include, in addition to the chairman and secretary-treasurer, a competent veterinarian, bacteriologist, chemist, clinician, and sanitarian or sanitary engineer who has a special knowledge of dairy methods.

The specific duty of a medical milk commission is to enter into a contract with an intelligent and conscientious dairyman who is sufficiently interested in clean milk to convert his own plant into a certified dairy. The commission should devote its main energy to supervising this supply and personally seeing that the dairyman faithfully supports both the letter and the spirit of the contract. The work of the commission does not end here, for each medical milk commission should be the centre for the movement of cleaner and better milk in its locality. It should be the

ferment for good which, through agitation, education, legislation, and other proper means, helps to improve the general public supply, so as to raise it towards the "certified" or "honor" class.

It has been found that the establishment of a medical milk commission and the production of certified milk is an excellent stimulus for the betterment of the general milk supply. As an example we may cite the experience of the Cincinnati Commission, which was appointed in May, 1906. At that time the conditions surrounding the milk supply were most deplorable. The following statement was made by a member of the commission: "As far as could be learned there was not one quart of clean, wholesome milk safe for infant consumption sold in Cincinnati. It was definitely known, and so stated by government experts, that the general milk supply was the filthiest of any city in the country." Many another city, when it has carefully examined existing conditions, has made the painful discovery that it has the "dirtiest" milk and most unsanitary milk conditions to be found in our broad land. After the Cincinnati Commission secured a supply of certified milk it persuaded a number of dairymen to produce a second grade of milk for household use, which was designated as "inspected milk." It then waged a campaign to abolish the use of wet distillery wastes in feeding milch cows. This was a vigorous fight which finally ended in victorious legislation. The commission then examined the milk supply of the hospitals of the city and found deplorable conditions. As a result two hospitals are now using inspected milk exclusively and several other hospitals are using inspected or certified milks in their children's wards. The fearless and vigorous campaign carried on by the milk commission in its pure milk movement had far-reaching results. A definite public opinion was crystallized, and the success obtained led the followers of the clean milk movement to demand from the city council a board of health,

free from partisanship, so as to place the general health affairs of the city upon a better plane. On August 1, 1909, a non-partisan board of health, established along ideal lines, was placed in possession of the health affairs of Cincinnati. These facts, from the activities of the Cincinnati Milk Commission, are given as an illustration of the good work that may be accomplished by a medical milk commission in addition to simply certifying milk.

The medical milk commission is not without its faults both of commission and omission. Some medical milk commissions are active, observant, helpful, and the centres of activity for the whole milk question of the community. More often the commission is composed of busy practitioners who have little time to devote to the problem and its details. The work is left in the hands of one member, usually the bacteriologist, who makes monthly or bimonthly counts.

Too often, when something goes wrong, the medical milk commission arbitrarily pounces upon the producer. Perhaps the certificate is summarily taken away. The producer does his best to locate the source of the trouble at once. He appeals to the medical milk commission for help, but is told: "That is not our business. It is not our duty to tell you how to make certified milk. It is 'up to you' to do it. We are only here to see that it is done." Now that is a very unfortunate attitude. The medical milk commission should coöperate in a helpful spirit, should study the problem and do all in its power to assist and help a conscientious producer in all proper ways. If deception, fraud, or left-handed practices are discovered, there is only one thing to do, and that is to take away the certificate permanently. The medical milk commission should remember that it is easy to break down, but hard to build up.

Perhaps one of the mistakes that certified milk commissions make is too great insistence upon non-essentials. To make certified milk requires a capacity for infinite de-

tails. Nevertheless the commission can err by magnifying unimportant points. What matters it whether the manure pile is twenty-five or thirty feet away from the barn and milk room so long as it is so located and so managed that odors, flies, and other objections are obviated? What matters it whether the milk house is ten or sixty feet from the barn? The methods, care, intelligence, and above all the conscientiousness with which the measures are carried out are infinitely more important than a few inches or feet, or a blind adherence to an arbitrary rule. It is results we are after. A good surgeon can perform an aseptic operation in a kitchen or a stable, although it is much easier to do so in a well-equipped modern surgical clinic. Likewise, intelligence and care play a similar rôle in the production of clean milk.

The medical milk commission is not always competent to decide questions of animal husbandry. In the milk question will be found farming problems which are quite distinct and may have little bearing upon the medical side of the problem. When the quality of the milk is not affected, it may be advisable to leave to the farmer the things that are the farmer's.

The certificate. The certificate must be a true certificate of character or else certified milk will fall. Therefore, not only the producer but the commission itself should zealously guard against any misuse or irregularity with the certificate. On the opposite page will be found a facsimile of a typical certificate.

The certificate does not guarantee that the bottle of milk to which it is attached is of the highest quality, of definite composition, and absolutely safe. It is only a general guaranty of the methods and reliability of the producer and his product, and a further assurance of a certain amount of supervision over both.

The certificate should always be dated. The only date of real importance is the date of production. Some milk

Philadelphia Pediatric Society.
MILK COMMISSION CERTIFICATE.

September 10, 1907.

Milk from [illegible] Dairy, Delaware Co., Pa., has been carefully examined by experts of the Milk Commission and found to be up to the required standards. Another examination is to be made within a month, and, if satisfactory, new labels for the bottles will be issued dated Oct. 10, 1907.

Notice the Dates.

P. S. P. [illegible]

MILK COMMISSION
CERTIFIED
ACADEMY of MEDICINE, CINTI. O.

THE WARELANDS
HIGHLAND LAKE, NORFOLK, MASSACHUSETTS
Medical Milk Commission of Boston Inc.
Certified Milk
MILKED
THURSDAY

MASSACHUSETTS AGRICULTURAL COLLEGE, AMHERST
Medical Milk Commission of Boston Inc.
Certified Milk
MILKED THURSDAY
TO BE SOLD
FRIDAY
DELIVERED BY
D. WHITING & SONS

MIDDLEBROOK FARM, DOVER, NEW HAMPSHIRE
Medical Milk Commission of Boston Inc.
Certified Milk
MILKED
SATURDAY
DELIVERED BY
H. P. HOOD & SONS

PROSPECT HILL FARM
Medical Milk Commission of Boston Inc.
Certified Milk
4%
MILKED
WEDNESDAY
J. A. & W. H. GOULD, ESSEX, MASS.

FORMS OF CERTIFICATES

commissions permit producers to date their certificates with the day of bottling. This has less value to the consumer than the date of production. Other commissions permit the certificates to be stamped with the date on which the milk is to be consumed. This is of practically no value at all, especially in the case of milk intended for ocean shipments, which, not infrequently, is consumed two weeks or longer after it is bottled. To require the certificate to be dated with the date of production may work a hardship upon farmers at a distance. Certified milk, if anything, should be fresh milk, and the producer is entitled to know its age when he receives it. To my thinking, special importance should be laid upon the fact that all milk should be fresh and that certified milk should be as fresh as it is possible to obtain it, and I will welcome the day when the health laws throughout the country will require the dating of all milk based upon the time of production. Recently I have found a March certificate on a May bottle of milk. This may have been due to carelessness of the bottler or to dereliction of the commission. Such occurrences are unfortunate. The certificate must mean just what it says or it is not worth the paper it is printed upon.

The producer. The producer, after all, is the most important person in the whole certified milk movement. It is important to encourage producers to come into the certified milk movement and to help them so that they may stay in once they have taken this advanced step. The man behind the guns is the real factor in producing good milk. The producer, on his part, should be frank and open with the commission, should come to the commission with his troubles, and thus mutual respect and helpfulness will pervade the entire certified milk movement.

Some of the producers of certified milk have actually done what the scientists regarded as an impossibility. Thus Mr. Stewart, at Brookside Farm on the Hudson, produces

a certified milk in rather large quantities almost free of bacteria. This is an achievement which ten years ago would have been said to have been impractical, if not impossible, by laboratory workers.[1]

The middleman. The statement is often made that the agents of the middleman or large contractor try to wean his customers away from certified milk and induce them to buy some cheaper milk. In any event, the impression is abroad among the producers of certified milk that the attitude of the middleman acts as a brake upon the wheel of the certified milk wagon.

Price. The average price of certified milk is about sixteen cents a quart. In a few instances certified milk is sold at twelve cents a quart, and the price may be as high as twenty cents or more. We should not grumble at the extra cost of certified milk. We should remember that it requires a bacteriologist, a veterinarian, a chemist, a clinician, and a skilled technician familiar with the dairy industry to produce this special class of milk. The extra price paid for certified milk is one of the cheapest forms of insurance against disease.

Amount. The amount of certified milk is now but a drop in the bucket. In Boston, New York, Philadelphia, and our other metropolitan centres the amount of milk certified is less than one per cent of the total supply. Many of our large cities, such, for example, as Washington, D. C., have no certified milk at all. This does not discourage us, for although the amount of certified milk is not large, its influence is great. The inevitable result of introducing certified milk into a community at once tends to raise the standard of quality of the common market milk.

The following states have laws concerning certified milk, namely, Kentucky, New York, New Jersey, and Massachusetts.

[1] See page 73 for Mr. Stewart's own description as to how he accomplishes these results.

Requirements for the production of certified milk. The following definition of certified milk and the conditions and requirements of its production, which I prepared in collaboration with Professor R. A. Pearson, Commissioner of Agriculture of the State of New York, for submission to the Certified Milk Producers' Association of America and the American Association of Medical Milk Commissions, gives the general requirements and special conditions required for the production of certified milk. This matter is given in some detail for the reason that certified milk represents the highest quality of milk possible to produce, and it is the ideal towards which all milk production should aim.[1] The following details therefore represent the best dairy practice: —

Certified milk is fresh, clean, pure, normal milk, of uniform composition and highest quality, obtained from healthy cows; produced and handled, under the supervision of a medical milk commission, with special sanitary precautions in accordance with the following general requirements and special conditions: —

GENERAL REQUIREMENTS

Certified milk shall be produced by a trustworthy dairyman in accordance with a code of requirements prescribed by a medical milk commission. The dairyman shall enter into a legal contract with the commission, in which he shall agree to comply with all its requirements.

Certified milk shall be obtained from healthy, tuberculin-tested cows under veterinary inspection; all persons who directly or indirectly come in contact with the milk shall be under medical supervision; and the milk itself shall be subjected to periodical bacteriological, chemical, and other tests.

Certified milk should be free from harmful germs and shall contain relatively few of the common bacteria. It should not con-

[1] The American Association of Medical Milk Commissions have just published "Methods and Standards for the Distribution of Certified Milk," *Public Health Reports*, XXVII, no. 24, June 14, 1912. This official publication is a comprehensive and detailed statement, containing all essential facts.

tain more than 10,000 bacteria per cubic centimetre, and shall not contain on an average more than 10,000 bacteria per cubic centimetre — this average shall be based upon bacteriological examinations covering a period of ninety days, and the counts shall be made at least once a week during this time.

Certified milk must be bottled at the point of production, rapidly chilled, kept cold, and delivered promptly to the consumer. After it is once chilled, the temperature of certified milk should at no time go above 45° F., but never below 32° F.

Certified milk shall be normal milk; that is, neither heated, frozen nor altered in any way except strained and cooled.

Certified milk shall be of uniform quality and contain not less than 3.8 per centum nor more than 4.2 per centum of fat, unless it is labeled otherwise, in which case it shall not vary more than 0.2 per centum from the amount stated on the label.

Certified milk shall not be subjected to the action of heat; shall not be subjected to the action of any preservative whatever, except cold; shall not be subjected to the action of light, electricity, pressure, or any special force or agency of any kind for any purpose; no substance of any kind shall be added to the milk for any purpose; and no part of the milk shall be removed.

Further, certified milk shall be produced under the following —

SPECIAL CONDITIONS

Location and character of lands

Pastures or paddocks to which cows have access shall be

(1) Free from marsh or stagnant pools.

(2) Crossed by no stream which might easily become dangerously contaminated.

(3) At sufficient distance from offensive conditions to suffer no bad effect from them.

(4) Free from plants which affect the quality of the milk deleteriously.

Surroundings of buildings

Surroundings of all buildings shall be kept clean and in good order. The accumulation of dirt, rubbish, manure, or decayed matter shall not be permitted. The stable-yard shall be well drained.

A GOOD TYPE OF INEXPENSIVE MILK HOUSE

THE INTERIOR OF ABOVE. CLEAN AND NEAT

Location, construction, lighting, and ventilation of stables and other buildings

Buildings in which certified milk is produced or handled shall be located where good drainage can be secured and at sufficient distance from other buildings, dusty roads, cultivated and dusty fields, and other possible sources of contamination, to avoid dirt, dust, or odors from such places.

Stables shall be constructed so as to favor the comfort of the cows. The floors shall be of cement or an equally non-absorbent material, and sloped to provide drainage. Stall floors may be constructed of sound plank well laid on cement.

The inside surface of the walls and all interior construction shall be smooth, with tight joints, and capable of shedding water. The ceiling shall be of smooth material and dust-tight. All horizontal and slanting surfaces which might harbor dust shall be avoided as far as possible.

The stable shall be as well lighted as the average house, and shall have an average of at least six feet of transparent window glass for each animal, with as much sunlight as possible and the light evenly distributed.

The ventilation shall be so efficient that one will not notice a stale, disagreeable, or strong odor on entering the building at any time.

Mangers and water troughs shall be constructed of iron, cement, or other equally non-absorbent material, properly sloped to provide good drainage.

All necessary measures shall be taken to prevent the entrance of flies and other insects, as well as rats and mice and other vermin in the stable or dairy buildings.

There shall be no cellar underneath a cow stable. The stable shall contain not less than five hundred cubic feet of air space per cow.

Condition of the stable in which the milk is drawn

The stable shall be kept scrupulously clean. Interior walls should be light in color. The walls and ceiling shall be whitewashed often enough to keep them clean and white and at least twice a year, unless such walls and ceiling are of smooth cement

finish or painted so that they can be washed frequently. Stables, dairies, etc., shall be thoroughly screened and additional efforts made to destroy and diminish flies.

Tools or apparatus, when not in use, shall not be exposed in the stable.

The stable shall be thoroughly cleaned at least once daily. Neither this nor other work which would stir up dust or odors shall be done within thirty minutes before milking-time.

While cows are being cleaned, the stable shall be thoroughly ventilated, and the floor may be sprinkled to reduce the dust.

At least every two months the mangers shall be scrubbed with a brush and soap, lye or washing-powder.

No horses, hogs, dogs, fowls, or other animals shall be allowed to come in contact with the certified herd, either in the stable or elsewhere.

No dusty or mouldy hay or straw, bedding from horse stalls, or other unclean materials shall be used for bedding cows. All soiled bedding must be removed daily.

Water supply

The whole premises used for dairy purposes must have a supply of pure water absolutely free from infection or objectionable pollution with organic matter, and sufficiently abundant for all purposes and easy of access.

Drainage

Drainage from buildings shall be carried underground to a point at least one hundred feet from any buildings used for producing or handling milk, and so far away that odors from the drain openings cannot find entrance to the buildings.

Removal of waste from stable

All manure and other waste shall be removed from the stable at least twice daily to a point at least one hundred feet from the stable or dairy building.

During the fly season of each year all manure and waste shall be removed daily to the fields and spread or otherwise disposed of so as to prevent the breeding of flies.

Stock — their health, grouping, housing, feeding, management, and care

The herd shall include no animal that is known to be diseased or that shows evidence of acute, chronic, local, or other disease.

No cow shall be added to a herd which has not successfully passed a tuberculin test within the preceding three months.

All cows in the stable where certified milk is produced must be tuberculin-tested at least twice each year as long as reactions are present, and once a year thereafter. The tests shall be made by a registered or licensed medical or veterinary practitioner approved by the milk commission, and those that react 2° F. or more must be removed from the herd at once.

All foodstuffs shall be kept in an apartment separate from the cows and used only after milking, and shall not be brought into the stable except just before fed.

Only those feeds shall be used which consist of fresh, palatable, or nutritious materials, such as will not injure the health of the cows or unfavorably affect the taste or character of the milk.

A well-balanced ration shall be used, and all changes of feed should be made slowly. The first feedings of grass, alfalfa, ensilage, green corn, or other green feeds must be given in small rations and increased gradually to full ration.

Long hair on the udder and surrounding parts shall be clipped. This does not apply to the bush of the tail. The tail must not touch the floor during milking.

Preparation of the cow for milking

The cow shall be cleaned, milked, and fed regularly and always treated kindly.

All sweeping of dry floors, walls, or ceiling must be completed before grooming of cows is begun. Dry sweeping and brushing should be discouraged.

At least half an hour before milking the cows shall be thoroughly groomed and cleaned and compelled to remain standing until milked.

Before each milking the udder and surrounding parts shall be thoroughly washed with clean water and clean cloths and

the udder wiped with a clean cloth tightly wrung out of clean water, and used only for the udder. Antiseptic solution may be used.

Health of employees

No person having an inflamed throat or suffering with any infectious or contagious disease, or who is known to be a typhoid carrier, shall be admitted to the stable or dairy building or be allowed to handle the milk, the milk utensils, or any object that directly or indirectly comes in contact with the milk.

No person who has been exposed at home or elsewhere within thirty days to any infectious or contagious disease shall be allowed in the stable or dairy building or to handle the milk, etc., until a physician certifies that it is safe for him to do so.

Children, strangers, and persons not actually employed in the work or its supervision should not be allowed in the barns, milk rooms, etc.

A milk commission may require regular reports from certified farms under its supervision as to the health of employees.

On account of the great importance of the health of the personnel the recommendations on the "Medical Examination of Employees" of the American Association of Medical Milk Commissions is here inserted: —

First. It should be ascertained whether any of the employees are in contact with persons suffering from any diseases, and whether that is contagious. If so, employee must leave the house in which the disease is, or be excluded from the milking-places.

Second. The employee must be examined for any disease of the skin. If a new employee comes to the farm, he should be examined for any disease of the skin which might have been contracted at the former farm, such as cow-pox, and excluded until all danger of conveying the disease is past.

Third. An employee should be asked whether he has ever had typhoid fever, as about four per cent of those having had typhoid fever have the typhoid bacilli in the gall bladder for years, and may pass them at any time by the intestinal discharge, and so convey them to the milk or other food. Examination should be made for the germs in any one having had the disease.

Fourth. A careful examination should be made for symptoms

of tuberculosis, either pulmonary or of the glands, and any one having it should not care for the milk.

Fifth. The mental capacity of the employee should be carefully considered, and the general disposition.

Sixth. When scarlet fever is known to be in the neighborhood, any one having a sore throat should be prohibited from handling the milk, as the sore throat might be that of scarlet fever.

This refers simply to the medical examination of employees, not to the sanitary condition of the premises.

Wm. H. Park, M.D., *Chairman.*
M. J. Rosenau, M.D.
Thomas Harvey, M.D.
Alfred Hand, Jr., M.D.

Preparation of the milkers: their cleaning: and their dress

Conveniently located facilities shall be provided for the milkers to wash in before and during milking.

Employees shall be clean in habits and appearance.

While engaged about the dairy or in handling the milk, employees shall not use tobacco or intoxicating liquors. They shall keep their hands away from their nose and mouth.

Before milking, the milker's hands shall be thoroughly cleaned by the use of soap and a brush and clean warm water and thoroughly dried on a clean towel. He shall be careful not to touch anything but the clean top of the milking-stool, the milking-pail, and the cow's teats. The hands shall be kept dry when milking. The milker's hands must be rinsed in clean water and dried after each cow is milked.

Milkers shall wear clean white suits and caps and shall use not less than two clean suits and caps each week. These suits should not be used except when milking. When not in use they shall not be kept in a dwelling, but in a clean, ventilated place where dust does not have access and provided especially for this purpose. The suits should be sterilized with steam once each day.

Helpers other than milkers

The requirements for milkers relating to garments and cleaning of hands shall apply to all other persons handling the milk, milk containers, etc., before it is ready for shipment.

Children under twelve should not be allowed in the stable or dairy during milking.

Collection of milk: hours of milking: methods of milking

The first three or four streams from each teat shall be drawn into a separate vessel and discarded. Milking shall be done in a quiet, clean, and thorough manner and at regular hours; as nearly as possible at twelve hour intervals.

If the milk of any cow appears bloody, stringy, or otherwise unnatural, the whole quantity yielded by that animal must be rejected. If dirt gets into the milk, the milk shall be discarded and the pail washed and sterilized before it is used again.

Cows producing milk other than for certification shall be milked after the certified herd or by other milkers. Cows producing milk not for certification should not be kept in the same barn with cows producing certified milk.

Shape, preparation and condition of vessels for receiving the milk

The milk shall come in contact with no vessel, apparatus, or container which is not clean and sterile.

The opening of the milk pail shall not be larger than a circle eight inches in diameter, preferably protected with a hood so as to avoid dust and dirt falling into the milk.

Location and condition of the dairy building

The dairy building shall be well lighted and screened and drained through well-trapped pipes.

No part of the dairy building shall be used for dwelling or lodging purposes.

The bottling-room shall be used for no other purpose than to provide a place for clean milk utensils and for handling milk.

During bottling this room shall be entered only by persons employed therein.

The bottling-room shall be kept scrupulously clean and free from all odors.

The utensils shall be promptly removed after use and cleaned in another room.

Straining, cooling, and bottling the milk

Promptly after milk is drawn, it shall be removed from the stable to a clean room, where it may be strained through a sterilized strainer of cheesecloth and absorbent cotton or any equally good strainer.

The milk shall be cooled within one hour to 45° F., and held below this temperature but above freezing until delivered to the consumer.

The milk shall be bottled promptly. It may be bottled without aeration, provided the cooling begins within fifteen minutes from the time the milk leaves the cow.

The milk shall be stored only in the dairy building.

Cleansing of milk containers

All milk containers and utensils shall be thoroughly cleaned by hot water and sal soda or other equally pure and efficient agent, rinsed until the cleaning water is thoroughly removed, then exposed to live steam or boiling water at least twenty minutes, then held until used where dust, vermin, and other contaminating material will not have access.

Packages for the transfer of milk

The milk bottles shall be of flint glass and free from permanently attached parts.

Seals

Milk bottles shall be sealed as soon as possible after filling, and they shall not be opened before delivery to the consumer. The method of sealing shall be approved by the milk commission.

Marking of milk containers

Caps to close milk bottles must be marked to show the claimed quality of the milk. All certified milk shall be conspicuously marked with the name of the commission certifying to it and be dated with the date of production. It shall further show the name of the producer, or other means of identification.

Transportation

At no time between the cooling of the milk and its delivery shall its temperature be allowed to go below the freezing-point or exceed 45° F.

Certified milk shall reach the consumer within thirty-six hours after it or any part of it was obtained from the cow.

Laboratory tests

Bacteriological and chemical tests of representative samples shall be made by the medical milk commission at least once a week and copies of the results should be forwarded to the dairyman.

Inspection

There are two ways of avoiding the dangers from dirt and germs in milk. One is to keep them out through care and cleanliness and the other to destroy the harmful bacteria by heat. We all prefer the first method, for it is the ideal one. Cleaner milk may be obtained through a system of inspection.

Inspection is primarily a health proposition. The object of inspection, as applied to the milk industry, is to give us cleaner, fresher, and safer milk. Inspection goes to the very heart of the problem. It starts at the farm and takes into consideration the health of the cows, the sanitary conditions under which the milk is produced, handled, and transported. It also takes into consideration the health of all those who come in contact with the milk and all other factors influencing its quality and purity. Not the least important object of inspection is the education of the farmer, the dairyman, the middleman, the common carrier and the consumer. An efficient system of inspection not only protects the consumer, but also safeguards the interests of the producer.

The principal objections to a system of inspection come from the farmer, because it is inquisitorial, and from the legislator, because it is expensive.

The farmer has a natural aversion to being inspected. The conscientious farmer believes, in his innocence and ignorance, that his methods are satisfactory and objects to the intrusion and criticism of a stranger. That is human

nature. Inspection, however, is in the air. It is bound to come because it is necessary. We all need a little watching. Supervision is a wholesome prod for the delinquencies of human nature.

Health officers all over the world find the conditions under which milk is produced to be very unsatisfactory and insist upon improvements. The only practical way so far devised to enforce the sanitary requirements is through a system of inspection. The farmer, therefore, may as well submit, for inspection is inevitable. The only questions before us, then, are who shall do the inspecting? how shall it be done? what system shall be employed? what shall be the qualifications of the inspector? how much authority should be given him? is the inspection to be under government, state, or local control? etc.

Inspection brings us fresher milk, cleaner milk, and safer milk, but it is difficult to conceive of any system of inspection that will supply us milk that will be free from infection at all times. In other words, the greatest dangers in milk come from invisible foes. The inspector cannot see the bacteria, he cannot detect bacillus carriers, and he cannot be blamed for failing to recognize mild types of disease, such as walking typhoid fever. While inspection is not an ironclad safeguard, it does furnish a reasonable protection: it insures cleaner and fresher milk; and a clean, fresh milk is much less apt to carry trouble than stale, dirty, and bacteria-laden milk. Because inspection has certain limitations is no reason why it should not be enthusiastically and vigorously indorsed by health officers and generously supported by legislators. It is probable that over ninety per cent of the ordinary troubles complained of in milk could be avoided through a competent system of inspection. The extraordinary dangers can be cared for through pasteurization.

The question is sometimes asked, Why should we go to the bother and expense of inspecting milk when pasteur-

ization alone will render it safe? No one wants dirty milk even though it is not specifically dangerous. There is an æsthetic side to our food problem which is not to be ignored. Further, dirty milk may be dangerous milk, even though pasteurized, for babies, invalids, and others. It will be shown that pasteurization does not atone for filth, that pasteurization does not improve the quality of milk, that pasteurization should never be used as a redemption process. In other words, pasteurization also has its limitations. The solution of the milk problem, therefore, consists in obtaining a reasonably clean, fresh supply through a system of inspection and then pasteurizing it to neutralize the dangers that cannot be seen by the inspector.

In Richmond, Virginia, Health Officer Levy greatly improved the sanitary conditions of the cow stables through a system of inspection and also effected a very marked reduction in the number of bacteria in the milk furnished that city.

In Rochester, New York, Dr. Goler also effected a decided improvement in the milk supply through an intelligent system of inspection coupled with practical demonstrations to the farmer showing him how to produce a clean and satisfactory milk. Dr. Goler believes that through these methods not only has the milk been greatly improved, but that a decided falling-off in the infant mortality has taken place.

In Geneva, New York, the quality of the milk was greatly improved by getting the producers to sell milk upon the basis of the score card.

Milk inspectors. To send an inexperienced man to inspect a dairy farm, at once places inspection among the extravagantly absurd measures. The farmer cannot but have a supreme contempt for the whole system when a young man from the city, with no experience of animal husbandry and with but a superficial knowledge of theoretical dairying, dictates to him what to do and what not

to do. If we want cleaner milk the inspector must have a practical knowledge of good dairy methods.

A good system of inspection must be helpful. The education of the farmer is one of its most important objects. The inspector, therefore, must not only be properly qualified as to experience and theory, but he must be tactful. It is much easier to criticize than to create. The inspector must not approach the dairyman with a club, but should obtain his good will and confidence, which will insure his coöperation. The inspector must remember that the science of bacteriology is young and its application to dairying still younger; hence the need of patience and forbearance.

A milk inspector should have had at least two years of instruction at a dairy school. He should then go the rounds with an experienced inspector in order to see the methods, learn the laws and regulations, and avoid the pitfalls and errors which a new inspector is apt to encounter. He then may be set loose for independent work.

The producer is much better off with an unprejudiced inspector from a distance than with a local man with whom he has a familiar acquaintance. The local man is apt either to slight or spite his work. The farmer, therefore, is much surer of a square deal from the stranger. Hence state inspectors are frequently more effective than local inspectors, and state inspection is apt to be more uniformly carried out.

Ordinarily an inspector of dairy farms can average six or eight dairies in a day. Under certain conditions, where well-known ground is being covered and the farms have frequently been inspected before, as many as twenty-five have been inspected in a single day. No inspector, however, can cover this number efficiently. An inspector should spend at least one to two hours on a place. In Chicago inspectors are required to visit forty-two dairies a week: in New York, the average is seven to eight a day.

In general it may be said that an inspector who reports upon fifty dairy farms a week is making a good average. From the administrative standpoint it would be better to require two hundred a month under ordinary conditions. At this rate one inspector is able to inspect about two thousand farms a year. The number of farms which may be inspected varies of course with the methods, their distance from each other, the roads, the means for transportation, etc. First inspections naturally take much longer than reinspections. Every dairy farm should be inspected not less than once in six months.

More inspection is needed in the early morning and late evening hours, when the cows are in the stable, and less at noon, when there is little to see. The inspector's visit should be unannounced and the route should be varied, for farmers soon learn to know when the inspector is in the neighborhood, which gives them a chance to clean up in preparation for his visit.

An honest, capable officer is more important than the law. It is easy to make laws and it is a simple matter to appoint inspectors, but it is practically impossible to purchase enthusiasm and conscientiousness, especially at the prevailing rates. People should not expect Pasteurs, Kochs, Darwins, Huxleys, or Newtons to apply for the position of milk inspector at a salary of from six to nine hundred dollars a year.

A good man may accomplish wonders with a poor law and imperfect regulations. A poor man will make a mess of it with good laws and perfect regulations.

The score-card system. Score cards and a tactful inspector are the essence of a good system. The score card is a mathematical photograph of the sanitary conditions of the dairy farm. Without a score card it is exceedingly difficult to make a thorough and systematic inspection; in fact, it would be quite impossible to do so without long experience. The score card has an educational value for the inspector

as well as for the farmer. Without a score card the memoranda made at the time of inspection are time-consuming and later confusing in editing, and mistakes readily creep in while working up the report. In brief, the score card is a convenient time-saving and part of a modern card-index system.

At first blush the score-card method seems to be a kindergarten procedure. It is evidently impossible to express biological conditions and grades of sanitary excellence in exact mathematical figures. The advantages of the score card, however, far outweigh its limitations. It is now in universal use wherever a good system of milk inspection is carried out. The history of the score card is somewhat doubtful. It was conceived by Dr. William C. Woodward, the efficient health officer of the District of Columbia, and was probably first put into effect by Mr. Lane, an officer of the Dairy Division of the Bureau of Animal Industry in the Department of Agriculture.

The score card should not be looked upon as a set of arbitrary rules, but rather as a system of rating. It becomes a record of the conditions. The score card promotes coöperation between the producer and the health authorities, for it brings the inspector and the farmer close together upon the details of the problem. Further, the score card promotes uniformity, which is one of the essentials of good administration.

The score card is the salvation of the producer in the case of an incompetent or dishonest inspector, because he has a written record of his faults of commission and omission. On the other hand, the score card protects the inspector against unreasonable attacks from the producer.

The score card has sometimes been objected to for the reason that it expresses its results mathematically. Theoretically this is a fault, but practically is one of the advantages of the system. It is evidently much better to say that a dairy scores fifteen, fifty or seventy-five per cent

than to use such general terms as "good," "bad," "indifferent." In actual practice it will be found that different inspectors will score a dairy almost exactly alike. Some of the individual items may differ, but the total average will probably not vary one or two per cent.

It is always advisable to score a dairy in the presence of the producer. In this way his coöperation may be enlisted. Every experienced inspector knows that many a farmer at first is skeptical and approaches the process of scoring his dairy and his methods with a feeling of disgust. This attitude frequently changes to a lively interest in the proceedings. The best inspectors are able to get farmers to score their own dairies. Thus they will say, "Now, what do you think you ought to have for the cleanliness of your dairy?" "How much do you think you ought to have for the health of your cattle?" "How much do you think I ought to take off for not removing the manure once a day?" etc., etc. Such methods accomplish real good and the farmer takes a pride in obtaining a higher score at subsequent inspections.

Score cards should always be made out in duplicate; one copy should be left with the farmer and the other kept on the files at the health office. The farmer should always have the right of appeal; on the other hand, the health officer should be prompt in correcting mistakes as well as loyally supporting the good work of his agents.

The question arises in the health office whether the scores should be published. Perhaps it is not advisable to publish the scores which are given at the first inspection. After gross faults have been corrected and the system placed upon a stable basis, it is then an advantage to publish the averages. The improvements thus shown are stimulating to the producer. A friendly rivalry arises in the neighborhood to obtain the highest scores. Even rewards may be offered. A high score pleases the producer, increases confidence in his product, and thus increases the

consumption of milk. It is also helpful, in that it gives a reason for increasing the price of milk. The consumer is not apt to begrudge one or two cents more a quart for milk from a dairy scoring eighty or ninety per cent.

One of the first questions to arise where the score-card system is introduced is, What shall be the lowest average which a dairy may score and still be permitted to sell milk? No specific limit can be stated which will apply generally, for the reason that the averages depend upon the particular score card that is used, upon the value of the various items upon the score card, upon the general tenor of the inspection as to laxity or strictness, and many other factors. As a general proposition it may be stated that dairies that score above ninety on a basis of one hundred per cent are establishments in the pink of condition where every known sanitary requirement is carried out with scrupulous care. These are the model establishments. Dairies that score between eighty and ninety are good, high class, and sanitary in almost all particulars and equipped to produce clean, safe milk. Dairies that score between seventy and eighty still belong to the reasonably good and clean class, and the milk they produce may be accepted for general market purposes. As soon as a dairy scores below seventy, it begins to come into the doubtful class. Below sixty, something is radically wrong, and dairies scoring under fifty should, under no circumstances, be allowed to send their product to the market. Mr. Weld states that the average score of the certified dairies scattered over the entire country is about 91 points out of a possible one hundred. The average score of the dairies connected with a dozen agricultural colleges and experiment stations was found to be about 72 points. Mr. Weld also reports that the Department of Agriculture at Washington has on record the score of about 30,000 dairy farms which were inspected during the year 1910, and these averaged between 51 and 52 points.

The condition of dairies supplying interstate milk to Boston is represented by the figure 45.06 per cent. The dairies furnishing Chicago's supply a year ago obtained an average score of 40. In Lancaster County, Pennsylvania, Mr. Whittaker found an average condition represented by a score of 39. A large number of inspections in the Middle West gave an average of 33. The first thorough scoring of the dairy farms supplying Richmond, Virginia, resulted in an average score of only 36.4. The Louisiana State Board of Health recently scored 345 dairies supplying 51 towns, with a general average of 31.6. An average of the highest scores was 44.4 and lowest 17.2.

As a matter of comparison it is interesting to note that in Chicago twelve per cent of the dairies scored below 30, while in Boston less than two per cent were in this low class.

For the purpose of comparison these averages may be misleading, for the reason that the dairy farms were scored by different persons using somewhat different methods.

The Milk Division of the Bureau of Animal Industry has recently inspected 571 dairies in New England furnishing milk to Boston. These dairies scored an average of 45.06 upon a score card having 100 as perfection. The scores were as follows: —

State	Number of dairies	Average score
Maine	32	48.81
Massachusetts	171	47.44
Connecticut	35	46.44
New Hampshire	220	44.48
New York	70	41.61
Vermont	43	40.27
Total	571	Average 45.06

From this exhibit it will be seen that Massachusetts is second only to Maine, but not noticeably in advance of Vermont, scoring lowest.

The following table is very instructive: —

Dairies scoring	Number	Per cent of total
Between 20 and 30	13	2.28
30 and 40	128	22.42
40 and 50	303	53.06
50 and 60	106	18.56
60 and 70	10	1.75
70 and 80	7	1.23
80 and 90	4	.70

A glance at this table shows that the great bulk of the dairies examined scored in the 30's, 40's, and 50's. Only three per cent of the 571 dairies examined score above 60 per cent.

In framing milk legislation it is advisable to introduce a clause that will permit even the poorer dairies to furnish milk for a reasonable time. This is for the purpose of allowing those who are already in the business to improve their conditions and comply with the requirements so as not arbitrarily to be forced out of business. Harsh and impetuous actions often defeat their own purposes, and the reaction may set back the cause of good milk for many years. At the same time the law should provide that no new producer may engage in the business unless he complies with the standards that will ultimately be established for all.

It must not be forgotten that there is only a general concordance between the quality of the milk and the score-card average. Naturally, milk produced by dairies with high scores will, on the average, be cleaner and better than milk produced by dairies with low scores, but this general statement does not always apply to specific instances. Thus I know of dairies which would not score 50 upon an average of 100. Nevertheless, these dairies produced milk containing an average of less than 10,000 bacteria per cubic centimetre. This is accomplished through intelligence, industry, cleanliness, and personal attention to the

essential details. On the other hand, we are all familiar with dairies, which, even though scoring high, nevertheless produce a poorer quality of milk. It is impossible to score intelligence, enthusiasm, and conscientiousness — qualities which play such an important rôle in the production of clean and safe milk.

Methods are much more important than equipment. This is one of the things that the score card does not take into sufficient account. Clean milk may be produced with clean methods and poor equipment, but good milk cannot be produced with a good equipment and poor methods.

In order to secure an efficient system of records and to facilitate the comparison of results, a number of score cards have been devised. The one most commonly used has been worked out by the Department of Agriculture, a copy of which is shown on page 176. This score card covers two features: equipment and methods. Under equipment is considered the health of cows, provisions for their comfort, food and its quality, the construction of stables, bottling-rooms, sterilizers, and other utensils. Forty points are allowed in the rating for perfect equipment. Under methods are comprised cleanliness of the cows, of the stables, ventilation of building, condition of the utensils, of the milkers, of the milk room, and methods of handling the milk and its prompt and efficient cooling. For perfect methods, sixty points are allowed.

The government score card also has on its reverse side a place for recording the number of cows, the number of gallons of milk produced daily, and the market to which the milk is sent, and finally a place for recording the quality of milk produced.

Michigan has devised a somewhat different score card comprising five features, allowing one hundred points for each. They cover: (1) the health of the herd and its production; (2) cleanliness; (3) construction and care of utensils;

(4) health of employees and manner of milking; and (5) the subsequent handling of the milk. A perfect score would be five hundred points. In addition, the general sanitary conditions are noted as good, medium, poor, etc. There is also a provision for recording the quality of milk under the heads of percentage of butter-fat, lactometer tests, total solids, and solids not fats. It must be evident that much of the value of such records will depend on the knowledge and judgment of the inspector and the thoroughness with which he does his work. It is also evident that an undue importance is placed upon equipment and too little value given to methods in most of the systems.

The foregoing has reference only to the production of milk in the dairies. Score cards should be used to control conditions in milk depots, in city dairies, in stores, and throughout the distributing system. Special score cards have been devised to meet these varying needs.

The score-card system of dairy inspection has made marked progress during the past few years. It is now in use by about one hundred and fifty cities and large towns. It has been formally introduced by state officers as a portion of their system of inspection in fourteen states, and at recent sessions of the legislatures in Idaho and Utah it was adopted in state enactments. The recent milk act passed by both houses of the Massachusetts legislature, but vetoed by the governor, contained specific provisions for the score-card system. Eighteen agricultural colleges give instruction in the best methods of securing dairy market milk through the score-card system of inspection. Eleven large milk dealers use this system in the dairies from which they buy their supplies. The method has been encouraged by the Government and is now generally recognized in dairy and medical literature.

A few illustrative score cards are here shown: —

Producers' and Distributers' Card—ROCHESTER BUREAU OF HEALTH—Division of Milk Inspection.

Inspector..... **Date**.....19....

Name.....**Town**.....**P. O. Address**.....

Marketed.....**Size of Stable**.....**Containing fresh cows**.....**Dry cows**.....

STABLE AND STABLE EQUIPMENT—A

		Perfect	Allowed
1	Cows { a If all healthy and tuberculin tested every six months and reacting animals removed.....50	50	
	Cows { b If tested once a year and reacting animals removed.....30		
	Cows { c If sickness of any other kind found deduct in accordance, even to full extent of score		
2	{ a Shavings for bedding.....5	5	
	{ b Clean straw for bedding.....4		
	{ c No bedding.....0		
3	Clean food and abundant.....5	5	
4	Water....Clean 2....Fresh 2....Abundant 2....Convenient 1.....7	7	
5	Small opening in milking pail or can (no wide mouth milk pails on premises)	25	
6	Clean milking suits—to obtain perfect score, suits must be used for milking only, and must be evidently clean	3	
7	Separate building for calving	1	
8	" " " sickness	2	
9	Well drained	5	
10	Free from contaminating surroundings	2	
11	Tight sound floor	3	
12	Proper gutter, at least 6 inches deep	2	
13	Smooth tight ceiling	3	
14	" " walls	2	
15	Proper stall, tie or manger	1	
16	Light by sq. ft. of glass per cow....4ft.—4....3ft.—3....2ft.—2....1ft.—1....*Deduct for Uneven Distribution*	4	
17	Ventilation Automatic—viz. King System 5....Adjustable—viz. Windows hinged from bottom 4	5	
18	Cubic feet of air per cow....500–1000 cu. ft.—4....500–400 cu. ft.—3....400–350 cu. ft.—2....Under 300 cu. ft.—0	4	
19	Arrangements for keeping barnyard dry—either covered or drained or graded ashes, cinders or gravel	3	
20	Arrangements for darkening and screening stable, viz. fly mat over door	6	
21	Arrangement for keeping cows standing after cleaning udders, viz. chains across stanchion	2	
		140–A	

		Perfect	Allowed
STABLE METHODS—B	1 CLEANLINESS.—This means that there should be no evidently old caked manure on cows and to be perfect there should be some evidence that the udders are cleaned before milking and udders should be clipped 10	10	
	Floor 2..Walls 1..Ceiling 2..Ledges 1..Mangers and Partitions 1..Windows 1 8	8	
	Air at Milking Time .For perfect there should be evidence that hay is not thrown down before milking 5	5	
	2 BARNYARD..Dry 3..Clean 2..Manure removed daily to field or proper pit 2 7	7	
	3 Discarding first draws from each teat 10	10	
	4 Washing hands before and during milking 5	5	
	5 Udders..Washed and dried 5..Cleaning with damp cloth 4..Cleaning with dry cloth 3 5	5	
	6 Milk removed from stable after milking each cow 5..As soon as milking utensil is full 4 5	5	
	7 Health of milkers and those on farm.—For some typhoid test of new comers 5	5	
	Unguarded or unreported infectious diseases such as Tuberculosis, Typhoid, Scarlet Fever or Diphtheria will make entire score 0	60-B	
EQUIPMENT—Milk Room—C	1 Location, convenience for producer 1..surroundings 2	3	
	2 Arrangement, proper rooms—This means that there must be a separate room for handling the milk while it is being bottled in which no other operation is carried on 2..convenience 1	3	
	3 CONSTRUCTION..Smooth floor 3..Smooth walls 2..Smooth ceilings 2	7	
	a Light	2	
	b Methods of darkening	1	
	c Ventilation..automatic—viz. King System 2..adjustable—viz. windows hinged at bottom 1	2	
	d Screen	5	
	4 Drainage, connected to sewer	4	
	5 Machinery and Utensils..cooling apparatus 5..bottling machine, easy of sterilizing 5..washing apparatus 4..Sinks 3..Drying racks 1..Crates 1..bottles, condition 1	20	
	6 Sterilizer..autoclave 40..Arnold type 35	40	
	7 Water, hot and cold, connected to public service	10	
	8 Pasteurizer..If producer actually Pasteurizes and so labeled, deduct 0; otherwise deduct 20 from score		
	9 Wagons..construction 2..condition 1	3	
		100-C	
METHODS—Milk Room—D	1 Cleanliness..floor 2..ceilings 2..walls 2..doors 1..windows 2..order 2..odors 2	13	
	2 Utensils..clean and sterile 25..Clean only 5	25	
	3 Handling..rapidity 5..freedom from exposure 5	10	
	4 Cooling..to 45° or below 20..45°—50° 15..50°—55° 10	20	
	5 Cold Storage..to 45° or below 20..45°—50° 15..50°—55° 10	20	
	6 Pasteurizing as before		
	7 Wagons—Cleanliness	2	
	8 Protection..iced 10..jacket or wet blanket 8..covered wagon or dry blanket 5	10	
		100-D	

Producers' and Distributers' Score: $\frac{A + B + C + D + \text{Bact. Score}}{5}$

SCORE-CARD USED BY CHICAGO SANITARY INSPECTION OF CREAMERIES AND PASTEURIZERS

EQUIPMENT	SCORE Perfect	SCORE Allowed	METHODS	SCORE Perfect	SCORE Allowed
Location	10	....			
Surroundings: clean 3, grass covered 1 4			*Buildings*	25	....
No open privies nearer than 300 feet 6			Cleanliness:		
Construction	15	....	Walls — painted 1, clean 2 3		
Floor: iron plate 4, cement 3, tile or brick 2, wood 1 4			Ceilings " 1, " 2 3		
Floor free from defects ... 2			Floors, including corners 4		
Walls and Ceilings: tile, cement, enameled metal and en. wood 4, plaster 1, rough wood 0			Windows, including ledges 2		
			Ledges, free from dust ... 2		
			Free from flies 8		
			Free from odor 3		
			Apparatus	25	....
Walls free from defects 2			Cleanliness:		
Fly screens on hand 3			Pasteurizer and cooler 5		
Sanitation	15	....	Separators and filters 5		
Light: window area 15% of floor space 4			Bottle fillers 5		
Ventilation: working system 6, windows 3			Bottle washers 2		
			Bottle rinsing tubs 4		
Drainage: ample 1, trapped 2, to 300 ft. away 2 5			Weighing and receiving vats 2		
			Pumps and pipes 2		
Pasteurizer and Cooler	15	....	(Deduct 10 points from score allowed if any of the utensils are not sterilized)		
Process: held 4, continuous 3 4					
Feed: regulate, and fixed ... 2					
Automatic thermo-regulator 3			*Containers*	20	....
Auto. thermo-register 3			Bottles:		
Easily cleaned and little piping 3			Well soaked and washed .. 3		
			Rinsed in running water and drained 3		
(If no pasteurizer and cows are all tested, allow 15)			Sterilized — live steam 10, dry heat 8 10		
Separators and Filters	3	....	Shipping crates washed 2		
Easily cleaned 3			Farmer's cans rinsed & washed 2 (Deduct 10 points if farmer's cans are not thoroughly cleansed and sterilized).		
Bottle Filler	5	....			
Automatic 5, hand 3 5					
Bottle Washer	5	....			
Machine 5, hand 4 5					
Other Utensils	5	....			
Smooth and well plated 3			*Handling of Milk*	10	....
Free from rust and defects. 2			Protection from dust and flies:		
Milk Pumps and Pipes	10	....	Covered vats 4		
Joints: all crosses 6, others readily taken apart 3 6			Covered aerators and coolers 4		
Smooth inner surface & plated 4			Bottle caps protected 2		
Water and Ice Supply	10	....	*Cooling and Storage*	10	....
Water: from deep well 5, spring 4, city main 3, running stream 2 5			Below 50 F. 10		
			From 51 F. to 55 F. 8		
			From 56 F. to 60 F. 4		
Ice: artificial 5, natural 3 (Allow 5 if water or ice supply has been examined and passed by Dept.) 5			Above 60 F. 0		
			Employes (Handling Milk)	10	....
Dressing-Room	7	....	Clothing clean 4		
Hot and cold water 2			Hands clean 4		
Sanitary lavatory, soap and towels 2			Hands free from sores 2		
Uniform working suits and caps 3			(Deduct 5 points from score allowed for smoking or expectorating in workroom).		
Total	100	....	Total	100	....

Score of equipment ..... Multiplied by 1 = ...
Score of methods ..... Multiplied by 2 = ...
Total ..... divided by 3 = ... *Final score*
Signed ..... (In full)
Food Inspector

PASTEURIZER, CREAMERY..... Date of Inspections.....

Owner.....Address.....

Shipments to Customers: via.....R. R.

Name..... } ..... Milk

Address ..... } ..... Cream

Name..... } ..... Milk

Address ..... } ..... Cream

Supt. ..... Insp't'r.....

Shipments leave at.....M.

Arrive at.....M.....Chicago

Also make Butter, Cheese, Condensed Milk, Casein — Milk Sugar

No. of Patrons..... Deliver at.....M

1. Do you make regular inspection of the dairies.....
2. Is a semi-monthly statement of Contagious Diseases on file from farmers.....
3. Are all cows supplying milk tuberculin tested.....
4. Are factory employes examined for Contagious Diseases.....
5. Pasteurizing hours .....
6. Has the water and ice supply been examined.....

   Sample No. ..... taken from shallow well.....feet deep

   Located.....ft. from outhouse; .....ft. from cesspool

   Results: Chemical..... Bact. ....

7. What make of Past. is used.....
8. What is the capacity.....per hour
9. To what temp. is milk heated.....
10. What is time of exposure.....
11. How soon is Pasteurized product cooled.....
12. To what Temp. is it cooled.....
13. Are the Temp. records on file.....
14. Give the average Temp. as recorded.....
15. Give instances of low Temp. recorded.....
16. Give personal observations of Past. Temp.....

NOTICE: .....

Owner, Agent, Tenant	Days Limit	Date Sued	Shutoff	Released	Abated

UNITED STATES DEPARTMENT OF AGRICULTURE
BUREAU OF ANIMAL INDUSTRY
DAIRY DIVISION

SANITARY INSPECTION OF DAIRIES

DAIRY SCORE CARD

Adopted by the Official Dairy Instructors' Association.

Owner or lessee of farm .....

P. O. address.....State.....

Total number of cows.....Number milking .....

Gallons of milk produced daily ....

Product is retailed by producer in .....

Sold at wholesale to.....

For milk supply of..... .....

Permit No..... Date of inspection....., 191

Remarks.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

(*Signed*).....

Inspector

DETAILED SCORE

EQUIPMENT	SCORE Perfect	SCORE Allowed
Cows		
Health	6	....
Apparently in good health 1		
If tested with tuberculin once a year and no tuberculosis is found, or if tested once in six months and all reacting animals removed 5		
(If tested only once a year and reacting animals found and removed, 2).		
Comfort	2	....
Bedding 1		
Temperature of stable.... 1		
Food (clean and wholesome)..	2	....
Water	2	....
Clean and fresh..... 1		
Convenient and abundant 1		
Stables		
Location of stable	2	....
Well drained..... 1		
Free from contaminating surroundings..... 1		
Construction of stable	4	....
Tight, sound floor and proper gutter..... 2		
Smooth, tight walls and ceiling 1		
Proper stall, tie, and manger 1		
Light: Four sq. ft. of glass per cow	4	....
(Three sq. ft., 3; 2 sq. ft., 2; 1 sq. ft., 1. Deduct for uneven distribution.).....		
Ventilation: Automatic system	3	....
Adjustable windows..... 1		
Cubic feet of space for cow; 500 to 1000 feet	3	....
(Less than 500 feet, 2; less than 400 feet, 1; less than 300 feet, 0; over 1,000 feet, 0		
Utensils		
Construction and condition of utensils	1	....
Water for cleaning	1	....
(Clean, convenient, and abundant.)		
Small-top milking pail	3	....
Facilities for hot water or steam	1	....
(Should be in milk house, not in kitchen.)		
Milk cooler	1	....
Clean milking suits	1	....
Milk Room		
Location of milk room	2	....
Free from contaminating surroundings 1		
Convenient 1		
Construction of milk room...	2	....
Floor, walls, and ceiling.. 1		
Light, ventilation, screens 1		
Total	40	....

METHODS	SCORE Perfect	SCORE Allowed
Cows		
Cleanliness of cows	8	....
Stables		
Cleanliness of stables	6	....
Floor..... 2		
Walls..... 1		
Ceiling and ledges..... 1		
Mangers and partitions... 1		
Windows..... 1		
Stable air at milking time....	6	....
Barnyard clean and well drained	2	....
Removal of manure daily to field or proper pit.....	2	
(To 50 feet from stable, 1.)	....	
Milk Room		
Cleanliness of milk room.....	3	....
Utensils and Milking		
Care and cleanliness of utensils	8	....
Thoroughly washed and sterilized in live steam for 30 minutes 5		
(Thoroughly washed and placed over steam jet, 4; thoroughly washed and scalded with boiling water 3; thoroughly washed, not scalded, 2).....		
Inverted in pure air..... 3		
Cleanliness of milking.....	9	....
Clean, dry hands..... 3		
Udders washed and dried..6		
(Udders cleaned with moist cloth, 4; cleaned with dry cloth at least 15 minutes before milking, 1.).....		
Handling the Milk		
Cleanliness of attendants	1	....
Milk removed immediately from stable	2	....
Prompt cooling (cooled immediately after milking each cow).....	2	....
Efficient cooling; below 50° F.	5	....
(51° to 55°, 4; 56° to 60°, 2.)..		
Storage; below 50° F.....	3	....
(51° to 55°, 2; 56° to 60°, 1.)..		
Transportation; iced in summer	3	....
(For jacket or wet blanket, allowed, 2; dry blanket or covered wagon, 1).		
Total	60	....

Equipment..... + Methods.....=.....*Final Score*

NOTE 1. — If any filthy condition is found, particularly dirty utensils, the total score shall be limited to 49.

NOTE 2. — If the water is exposed to dangerous contamination or there is evidence of the presence of a dangerous disease in animals or attendants, the score shall be 0.

Federal inspection. It is evidently impossible for the Federal Government to cover the entire country with an efficient system of milk inspection capable of meeting all the demands of the case. It would require an army of inspectors and an enormous outlay of money, and create a ponderous and unwieldy bureau which would help to defeat the object sought. The activities of the Federal Government are largely limited to the milk which enters interstate traffic. The advantages of centralization are plain, but in view of our dual form of government the authority from Washington has no legal power over milk which does not cross a state line.

The Federal Government has taken an active interest in the milk problem in at least two of its great departments. The Department of Agriculture, in its Milk Division of the Bureau of Animal Industry, has shown commendable zeal and has been very helpful in stimulating progress, promoting local legislation, and pointing out the needs of the case. The Dairy Division of the Bureau of Animal Industry makes a special study of the sanitary production and handling of milk, investigates problems of transportation and distribution, examines ordinances, laws, and methods of inspection, and disseminates this information by printed literature, correspondence, lectures, personal visits, and exhibitions of various kinds.

This branch of the Federal Government is not a far-away affair, but comes to our very doors, as shown by its recent activities in New England. Thus agents of the Government have visited, for the purpose of explaining the score-card system of dairy inspection, Springfield, Fall River, Worcester, Salem, and Holyoke in Massachusetts. Recently government officers have investigated the dairies supplying Boston with interstate milk, and a similar investigation of Massachusetts dairies is now under way.

The Bureau of Chemistry of the Department of Agriculture, formerly presided over by Dr. Harvey W. Wiley,

has also accomplished much good in prosecuting those who sell adulterated milk in interstate traffic. The Public Health and Marine Hospital Service has shown its interest in the situation, through scientific research and otherwise. It has published a comprehensive volume upon "Milk and Its Relation to the Public Health." In this and other ways the Government is lending a helpful hand. The Washington authorities will always coöperate with state or local authorities, and much good has been accomplished in this way.

State and local inspection. The duty of inspecting milk devolves either upon the state or local authorities, since the Federal Government lacks authority to deal with the whole question. Whether the inspection should be done by the state alone or by the cities and counties alone, or by both, is often a confusing and perplexing problem. There are advantages and disadvantages which must be considered. To my thinking, however, the problem will best be met by the state taking the active and predominant rôle, in coöperation with a system of local inspection.

The advantages of a state-wide system of inspection are manifold. A central system promotes uniformity in methods and economy in operation. The inspection is also apt to be more efficient, for the reason that a state inspector has a wider experience and broader horizon and comes to the farmer unprejudiced as a stranger. The state system of inspection further reaches certain phases of the problem that the local authorities alone may neglect. For example, the local authorities in Worcester may forbid the sale of milk in that city, coming from a dairy farm situated in Worcester County. Without state stewardship over the situation, there is nothing to prevent this farmer sending his milk to Boston, Springfield, or some other city in the commonwealth. As a matter of fact there is nothing in the present laws of Massachusetts to prevent such a transaction. Instances are on record in which milk forbidden in

Brookline has been taken to Cambridge, Charlestown, or Malden. This could readily be prevented without the intervention of the state authorities by a close and cordial coöperation between the local authorities. It must, however, be plain that the control of the situation by a large number of small units is difficult, impracticable, and well-nigh impossible. It requires a strong central hand.

Another weakness in local option is lack of uniformity. It has been found impossible to get all the cities and towns of a state to adopt uniform laws and regulations, and should this come to pass there would be wide discrepancies in their administration. It is unjust and unnecessary to enforce much more stringent requirements upon a farmer in one county than his neighbor in another, and it is dangerous and a disgrace to permit the opposite to take place.

It is not in human nature for the local authorities to enforce the regulations with the same stringency and efficiency for milk produced in a county but sold at a distant point, as they do for milk produced in the county and consumed at home. Where local option is enforced and state power is nil, the larger cities must depend entirely upon the efficiency and integrity of the local inspectors.

One of the serious objections to the local system is the multiple inspection and unnecessary duplication of work, and the resulting confusion that is thus thrown into the situation. Farmers producing milk in one county would be subject to inspection by all the other counties to which the milk is sent. This lack of centralization is very perplexing and confusing, especially where both state and local authorities have independent power. Thus in Massachusetts a dairy farm may be subject to many different inspections: for example, a farm in Barre will be visited by the state milk inspector; will also be inspected by an agent of the Boston Board of Health because the milk is sent to Boston; and further, is subject to inspection by the local authorities at Barre. If the milk is sold to one of the large

contractors the farm will also be examined by one of the inspectors employed by the contractors. Finally, if some of this milk should be sent to New York City it would be subject to inspection by the authorities of that city. Even two inspectors are confusing to the farmer, but more than two are ruinous.

A central inspection has many other advantages that may not at first sight be obvious. It facilitates both the recognition and control of milk-borne diseases. It is useful in animal husbandry in controlling the movements of cattle, in the early recognition of the prevalence of animal diseases, such as anthrax, rabies, actinomycosis, foot-and-mouth disease, etc.

The weakest link in the sanitary chain is the country health officer. Many country health officers have not even a medical education. In fact, many counties and small places do not even have such an officer. Milk comes from the country and especially from thinly settled districts lacking in health laws and in health knowledge. If the city must depend upon the country health officer for the purity of its milk supply it is sadly handicapped. This is one of the greatest of all the disadvantages of local milk inspections.

On the other hand, the feeling for home rule is strong, and there are many reasons why it should be encouraged. It is an advantage to the local community as well as the entire country to strengthen the hands of the local health authorities. In some states the larger cities have taken such active steps in the question of milk inspection that they dominate the situation in the state. This is largely the case with New York City and Chicago and, to a certain extent, with Boston. A number of the smaller towns are also doing admirable work, such, for example, as Springfield and Fall River. As soon as a city or town adopts efficient and stringent regulations for the control of its milk supply, it is apt to bring about a curious situation. It stimulates a desire among dairy people for a state inspec-

tion to supplant the city inspection, with a hope that the state-wide system will be more dilute and therefore less exacting. It is true that large cities with ample resources are, as a rule, able to grant more generous ways and means and concentrate their efforts with greater success than is apt to be the case with a large and populous state.

The relations between the state and city health authorities are somewhat analogous to the relations between the federal and state authorities. In the last analysis it appears that the milk question is so large, so complex, and so important that it requires the activities of all three agencies with cordial coöperation between them. The Federal Government has a distinct but limited place in the situation; the state authorities should have the large and overshadowing power; and the local authorities must be active and helpful. A strong pull and a long pull all together will give us better milk and will help to protect the consumer, and will also safeguard the interests of the producer.

Neither the local authorities nor the state authorities have direct power to inspect dairies in another state. This question of interstate milk, however, may be reached through a system of licensing; that is, a milk dealer in Vermont need not submit to an inspection by an agent from the state of Massachusetts or from the city of Boston, but either the city of Boston or the state of Massachusetts can say to the Vermont farmer: "You cannot sell your milk in our city or state unless you permit our inspection and comply with our sanitary requirements." The refusal to permit the inspection may be taken as *prima facie* evidence that the dairy is in unsanitary condition or the methods unsatisfactory, and the milk may therefore be refused. No out-of-state milk need therefore be accepted except from licensed producers. As a great proportion of the milk of all large cities comes from other states, the control of this interstate traffic through the indirect method

of the license becomes an essential part of the system of milk inspection.

The milk license or permit

It seems just as important to license persons engaged in the milk industry as it is to license plumbers, undertakers, or trained nurses; in fact, to the sanitarian the dangers from bad milk are much more frequent and serious than the dangers from defective plumbing and that old fetish, sewer-gas. Licenses should be issued and required of all those who produce or deal in milk. From the standpoint of out-of-state milk it is especially important to license the dealer, and then permit him to sell only such milk as has been produced and handled in accordance with the sanitary requirements, whether within or without the state. A chauffeur cannot run an automobile without a license, and is not licensed until he can demonstrate to the satisfaction of somebody that he is reasonably competent. Automobile accidents are very obvious, and the public is careful to take measures to prevent them. Would it not be just as reasonable and much more necessary to license persons who endanger life and health through milk? It is true these dangers are not so obvious, but they are just as real and just as serious.

Several cities have successfully inaugurated a license or permit system, notably New York City and Washington, D.C. In these cities the registration or permit system has proved itself exceedingly valuable and has demonstrated its many advantages. It centralizes in convenient form all the information concerning the milk industry, it keeps track of the number, size, location, and other factors concerning each dairy, it facilitates the early recognition of epidemics, and is very helpful in discovering their cause. In addition to the many other advantages it may even prove a source of revenue. It seems, however, unjust to charge more than a nominal sum for the license, for the

reason that the inspection is done largely for the benefit of the consumer, and the state at large should pay the toll. It is evidently unjust to levy a special tax upon the producer to meet the expenses of the system.

The license should contain pertinent facts with reference to the place or places in which the business or any part of it is carried on, and should be valid for one year from date of issue. The license should be issued only after a careful inspection, and should serve as a sort of diploma of the fact that the licensee is capable of producing or handling milk in a cleanly manner. The licensed dairyman should, in addition, be required to post a complete and accurate list of the producers from whom he is obtaining milk for sale. This list should contain the full names, residences, and place of business of such persons and should at all times be displayed for public inspection.

Licenses should at any time be suspended or revoked for due cause. This is a much severer penalty than the usual fine which is imposed.

Every producer and dealer should be required to have a license no matter what the size of the business. Some cities and states exempt the two- or three-cow dairy. Thus Massachusetts exempts anything less than twenty quarts a day. This exemption, however, in my judgment, is pernicious, as the small dairyman needs the inspection and sanitary supervision quite as much as the large one.

CHAPTER VI

PASTEURIZATION

Pasteurization is the simplest, cheapest, most effective, and least objectionable method of destroying dangerous germs in milk. Pasteurization, therefore, prevents sickness and saves lives. However, pasteurization has limitations and objections that must be considered. Like all good things it is subject to misuse and abuse.

In the discussions upon pasteurization the process is held up either as a badge of honor or a mark of disgrace. It is neither. Pasteurization is simply an acknowledgment that raw milk may be dangerous milk and that heating is the simplest and most effective way of eliminating these dangers. Pasteurization is the cheapest form of life insurance the consumer can take out. It is also a business insurance for the producer and dairyman. There is still much misconception concerning the object of pasteurization and considerable misinformation concerning just what pasteurization really is. Pasteurization does not mean sterilization. A clear distinction must first of all be made between sterilized milk and pasteurized milk.

Pasteurization and sterilization

By pasteurization we mean simply the heating of milk to a temperature below that of boiling for a short period of time, followed by rapid cooling. In the language of the kitchen, pasteurization means "parboiling." As we understand it to-day, the object is not to preserve the milk, but only to destroy the harmful bacteria. Only some of the bacteria are destroyed in pasteurized milk. Many survive, and continue to grow and multiply. Pasteurized

milk, therefore, spoils just as raw (that is, unheated) milk spoils. Pasteurization does not mean simply the heating of milk, for the subsequent rapid cooling is a very important part of the process. If heated milk is allowed to cool slowly it remains at a temperature between 20° and 37° C. for a very long time. This is the best temperature for the development of bacteria and their poisonous products. It requires but a few hours under such conditions to develop an enormous brood of bacteria.

Sterilization means the destruction of all microscopic life that may be in or on an object. Even boiling will not sterilize milk, because some of the hardy spores resist the boiling temperature. Milk that has simply been boiled will, therefore, spoil and decompose in a particularly undesirable way; that is, it putrefies, rather than ferments. Putrid milk is alkaline and apt to be poisonous: fermented milk is acid and sours normally. To sterilize milk it is necessary to heat it at a temperature of 120° C. for fifteen minutes, or to boil it for half an hour on three successive days. The reason for this is that the spores which escape the first boiling germinate in the milk and are destroyed at the second boiling. Two boilings may be enough, but a third is occasionally necessary. A flask of sterilized milk, if protected from re-contamination and kept from evaporation, will remain unchanged indefinitely.

Much confusion has arisen from a failure to understand the difference between sterilized milk and pasteurized milk. Many of the undesirable properties of boiled milk, or milk heated to a high temperature, do not apply to milk pasteurized at the lower temperatures, which modern research has shown to be sufficient.

Historical

Pasteur in 1860 to 1864 studied the diseases of wine and found that it was sufficient to heat wine for a few moments at a temperature of from 50° to 60° C. in order to prevent

souring and abnormal fermentation. In 1868 the successful experiment was made of sending a cargo of heated wine around the world upon the frigate La Sybile.

Following the Franco-Prussian War, Pasteur studied the diseases of beer and found that this beverage could be preserved by heating it to a temperature of from 50° to 55° C. for a short time. The pasteurization of beer and wine has been so successful that the process is now in current use to preserve these readily decomposable liquors. The application of the process gave rise to the new term "pasteurization," which soon became current in technical language.

It was not until 1886 that the distinguished chemist, Soxhlet, advised the heating of milk for infant feeding and described an apparatus for carrying out the process in the home. To Soxhlet will ever remain the merit of having first systematized and popularized the heating and the special care of milk for infant use. In addition to heating the milk, Soxhlet divided the day's quantity into nursing-bottles, so shaped as to be readily cleansed and sterilized; — upon the importance of all these points he properly laid stress. Soxhlet made the mistake of regarding milk heated for a brief period at about the temperature of boiling water as sterilized milk. He also placed undue stress upon a special stopper which hermetically and automatically sealed the flasks in cooling. Soxhlet's methods are still popular in Germany, but the European methods, which to a large extent attempt to sterilize the milk, have thrown considerable confusion as well as discredit upon the subject of pasteurization as practised in America.

In 1889 Jacobi, who had long practiced and taught the wisdom of heating milk for infant feeding, makes reference to the use of Soxhlet's apparatus in the "Archives of Pediatrics." This is the first reference in American science to the subject. It was soon pointed out by bacteriologists that Soxhlet's process was not sufficient to sterilize the

milk, and that the surviving spores developed and grew and, according to Flügge, were capable of producing harmful results. Further, it was found that the heating of milk for prolonged periods at a high temperature was neither necessary nor desirable, and recourse was then had to the pasteurization process.

The object of pasteurization

Pasteurization should only be used to destroy the harmful bacteria in milk and for no other purpose. It must not be used as a redemption process. It cannot atone for filth. It should never be used to bolster up bad milk. It should never be used as a preservative; heated milk keeps somewhat longer than raw milk. From the standpoint of the sanitarian, pasteurization is a valuable public health measure because it prevents disease. From the standpoint of the dairyman, it is sometimes favored because it preserves milk. This is a collateral advantage to which the dairyman is entitled commercially. However, when milk is properly pasteurized at the correct temperature and time it keeps only about twelve to twenty-four hours longer than it otherwise would. Milk may be kept from souring another twelve or twenty-four hours by pasteurizing it again. This should not be permitted, for milk should be handled in such a way that double pasteurization should not be necessary.

Pasteurized milk not necessarily good milk

Harm has been done by the misuse of the term "pasteurized milk." It has popularly been construed to mean a superior quality of milk. Pasteurized milk simply means heated milk, and is not necessarily synonymous with clean milk, good milk, or pure milk. In order to correct this misconception concerning pasteurized milk it would be better to discontinue the use of the term and to use in its place "heated milk," stating the degree of heat and the

time of exposure on each bottle, as well as the date on which the milk was heated.

Pure milk is better than purified milk

It is self-evident that pasteurization is an expedient and not an ideal. It must be quite evident to any one who gives the matter thoughtful attention that the heating of milk is like the use of antiseptics. Antisepsis was a great improvement in surgery, but asepsis, or the absence of germs, is the ideal. The surgeon however must have antiseptics to attain asepsis. In the same sense the heating improves bacteria-laden and infected milk, but clean milk is the end we must seek.

The question of obtaining a safe milk in the enormous quantities necessary to supply large cities is so far from solution that some milk experts believe that pasteurization is not a temporary expedient, but will always be necessary because it is economically justifiable for the milk used by adults and for ordinary household purposes. This opinion is perhaps justified because the heating of milk does not injure its nutritive value. If the heating is properly done, pasteurized milk cannot be distinguished from raw milk either by taste, odor, or appearance. Even laboratory tests cannot tell with certainty whether a milk has been heated to 60° C. for twenty minutes or not; yet such milk is free from the danger of conveying tuberculosis, typhoid fever, diphtheria, scarlet fever, and dysentery, and is safer for infants.

Preventive measures are better than corrective ones

Milk should be produced under clean conditions and kept clean, and then it would not have to be purified. But we must guard against enemies so long as they exist. We would all like to do away with the necessity for armies and navies, but present conditions demand their maintenance. The same is true of the harmful bacteria in milk.

So long as the average market milk is apt to contain these insidious foes, the only protection we have is to destroy them with heat.

It must be remembered that even with the most exacting care known to science milk occasionally is apt to become infected. This sometimes happens to the cleanest, freshest, and purest grades. Even certified milk has, on several occasions, been responsible for diphtheria and scarlet fever. The reason for this is that cases of these diseases are sometimes so mild that they cannot be recognized even by a skillful clinician. Finally the danger is unfortunately complicated by the occasional presence of a bacillus carrier. A number of outbreaks of typhoid fever have been traced to bacillus carriers.

Why pasteurization is forced upon us as a public health safeguard

Raw milk is apt to be dangerous milk. Pasteurization is our only safeguard against certain of the dangers conveyed in milk. The question now arises whether these dangers are sufficiently real or sufficiently frequent to justify all the fuss that is made about them. Is the danger from the use of the average raw market milk a serious one? Yes, it is. The numerous outbreaks of typhoid fever, scarlet fever, diphtheria, sore throat, as well as the relation of milk to tuberculosis and other infections, is sufficiently real, sufficiently frequent, and sufficiently serious to arouse sanitarians and the public to a realization of the danger. In our studies on typhoid fever in Washington, for example, we found that the general market milk is, for the most part, old, stale, and dirty. Further, that at least 11.3 per cent of the cases of typhoid fever which occurred during the summer of 1906 in our capital city were due to infected milk; in 1907, 9.18 per cent; and in 1908, about 10 per cent of the typhoid cases were traced to infected milk. Similar conditions have been found in other cities wherever the

matter has been investigated. One needs only to make a superficial study of the subject to be impressed with the number of deaths and diseases caused by impure milk. In pasteurization we have a simple and efficient method to prevent these dangers. Pasteurization is justified independently of the question of infant morbidity and mortality. That is another story.

Until the health officer can assure us that the market supply of milk is clean and safe we are forced to protect ourselves. It is perfectly plain that we cannot get a safe and satisfactory milk supply for our metropolitan cities to meet all sanitary requirements in this generation. Until the health officer can assure us that it is perfectly safe to drink the milk raw, we should pasteurize it just as we should boil drinking-water that we know is liable to contain infection.

Safeguarding the efficiency of pasteurization

Pasteurization should be under the control of the health officer. Pasteurization is too important a public health measure to leave to the caprice of the individual. The process should be under strict surveillance, and guarded by health laws and regulations. The responsibility of the health officer in this regard is evident. It is his duty to see that the temperature and time of pasteurization are correct, that the milk is not heated too high, nor too long. If the milk is not heated high enough nor long enough the serious germs may escape and a sense of false security established. The rapid chilling and handling of pasteurized milk must be carefully looked after and controlled by the health authorities. All pasteurizing apparatus should be equipped with an automatic registration of the time and temperature. This apparatus should be under the lock and seal of the health authorities and should be carefully tested from time to time to insure accuracy.

It is further the duty of the health officer to see that pas-

teurization is not abused in other ways. He should not permit any old milk to be pasteurized. Milk which does not conform to the sanitary standards should not be permitted to be pasteurized, just as such milk is now not permitted to be sold in its raw state. Further, the health authorities must keep a watchful eye upon the after-care and sale of pasteurized milk.

The care of pasteurized milk

Pasteurized milk must be handled at least as carefully as raw milk. Pasteurized milk is just as apt to become infected or re-infected, if exposed, as raw milk. Bacteria grow more rapidly in heated than in fresh raw milk. The germicidal properties of the milk are destroyed by heat, and the surviving bacteria do not have so hard a struggle for existence in the heated milk. It is, therefore, exceedingly dangerous to place pasteurized milk in bottles that are not biologically clean. It is nothing short of crime to place any milk, raw or cooked, in bottles that have not been properly disinfected.

There is a plentiful lack of understanding concerning the relative growth of bacteria in raw and heated milk. From a practical standpoint the question can be totally disregarded, for the germs that concern us particularly, such as typhoid, diphtheria, and others, are just as harmful if introduced in raw milk as in pasteurized milk. As a matter of fact, all the epidemic outbreaks of the milk-borne diseases that have been studied have been traced to the use of raw milk. There is not a single instance on record in which a milk-borne outbreak is recorded from the use of pasteurized milk.

The so-called germicidal properties of milk are active only in the fresh product; that is, during the first six or eight hours after milking. When milk is older, the bacteria grow quite as well in raw milk as they do in heated milk. As practically all of the market supply of large and small

cities is more than six or eight hours old, the question has only an academic interest.

Personally, I cannot see why pasteurized milk needs greater care than raw milk. Both require careful handling — and neglect is just as serious in the one case as in the other.

How long will pasteurized milk keep?

The keeping qualities of pasteurized milk have been much discussed, and laws have even been proposed forbidding the sale of pasteurized milk after it is forty-eight hours old. Thus the sanitary code of the city of New York states that "pasteurized milk must be delivered to the consumer within twenty-four hours of the pasteurization." The number of bacteria allowed in a pasteurized milk has not yet been made the subject of law. As a general rule there is a reduction of about ninety to ninety-nine per cent of the bacteria contained in the raw milk, provided the raw milk is not excessively dirty and provided the pasteurization is effectively done. The surviving bacteria continue to grow and multiply until they reach into the millions per cubic centimetre. The question now being considered by health officers and milk experts is how many bacteria should be permitted in pasteurized milk offered for sale. To be on the safe side it may be said that pasteurized milk should not contain over 50,000 bacteria per cubic centimetre.

This question has long been considered a very serious one, for the reason that it is commonly believed that pasteurized milk does not sour normally, but putrefies with the production of poisonous toxins. Fortunately this is not the case with milk pasteurized at the temperatures now recommended. In other words, pasteurized milk spoils just as raw milk spoils.

It is not generally known that pasteurized milk sours normally. The fable that pasteurized milk turns putrid was imported from Germany, where sterilization was at-

tempted. It is true that if milk is heated to or near the boiling temperature it afterwards putrifies, but temperatures between 60° and 65° C. do not kill all the lactic acid bacteria. Ayers and Johnson showed that milk as it is pasteurized in America sours normally. These results have been confirmed by the Chicago Board of Health and also by Dr. Schorer in my laboratory. Therefore the bugaboo that nature's danger signal is destroyed in pasteurized milk vanishes before the facts.

Pasteurized milk, therefore, does not keep much longer than the raw milk, and the question of the limitation of the age of pasteurized milk, therefore, partly answers itself.

Laws and regulations concerning pasteurization

The cities of New York and Chicago were the first to recognize pasteurization as a public health measure upon the statutes and to proclaim laws regulating its practice.

There is no regulation of the health department of the city of Boston covering the pasteurization of milk and milk products. In the year 1908 a state law was adopted by Massachusetts, which, however, is inoperative because of the high temperature specified therein (167° F.).

In Chicago, Commissioner Evans promulgated comprehensive regulations anent the pasteurization of milk and milk products. These regulations go into the subject in commendable detail.

In New York City the sanitary code of the department of health adopted regulations April 22, 1908, containing rules for pasteurization, amended January 4, 1912.

Other cities and states appear backward in promulgating laws and regulations upon the subject of pasteurization.

The temperature and time of heating

The dominant factor that controls the temperature and time at which milk should be pasteurized is the thermal

death-point of pathogenic bacteria. These must be surely killed so as to eliminate the danger. So far as we are able to judge from our present knowledge the best temperature is 60° C.[1] continued twenty minutes. A higher degree of heat for a shorter time is just as effective so far as the destruction of the bacteria is concerned.

It may be stated with confidence that the tubercle bacillus, the typhoid and the dysentery bacilli, the diphtheria bacillus, the cholera vibrio, the specific cause of scarlet fever, the streptococci, and other harmful microorganisms which get into the milk are rendered harmless by heating to 60° C. for twenty minutes. I am dogmatic upon this point because I have made it the subject of much study in the laboratory. Further, the experience and experiments of many scientists who have investigated this subject are very clear upon this point. It is fortunate that the thermal death-points of the pathogenic bacteria that most concern us are below those of the ferments in milk, for in this way the infections may be destroyed without seriously altering the quality of the milk.

Different times and temperatures, however, are used to pasteurize milk. The historical development of this part of the subject is interesting. At first sterilization was attempted at or above the boiling-point. It was soon shown that boiling does not sterilize milk, and further that a high degree of heat is not necessary. A more precise knowledge of the objects to be attained has gradually resulted in lowering the temperature and shortening the time. Temperatures varying from 95° to 60° C., and periods varying from a moment to two hours, have been variously recommended for the pasteurization of milk.

The temperature and time recommended by various authorities for milk pasteurization follow (page 196): —

[1] That is, 140° F.

Authorities	Year	Temperature (°C.)	Time (minutes)
Freeman [1]	1898	68	30
Freeman [2]	1907	60	40
Forster [3]	1892	70	5–10
Smith, Th. [4]	1899	60	20
Oppenheimer [5]	1899	70	30
Hippius [6]	1905	60	60
Bitter [7]	1890	68–59	30
Hesse [8]	1900	60	15–20
Russell & Hastings [9]	1900	60	20
Rosenau		60	20

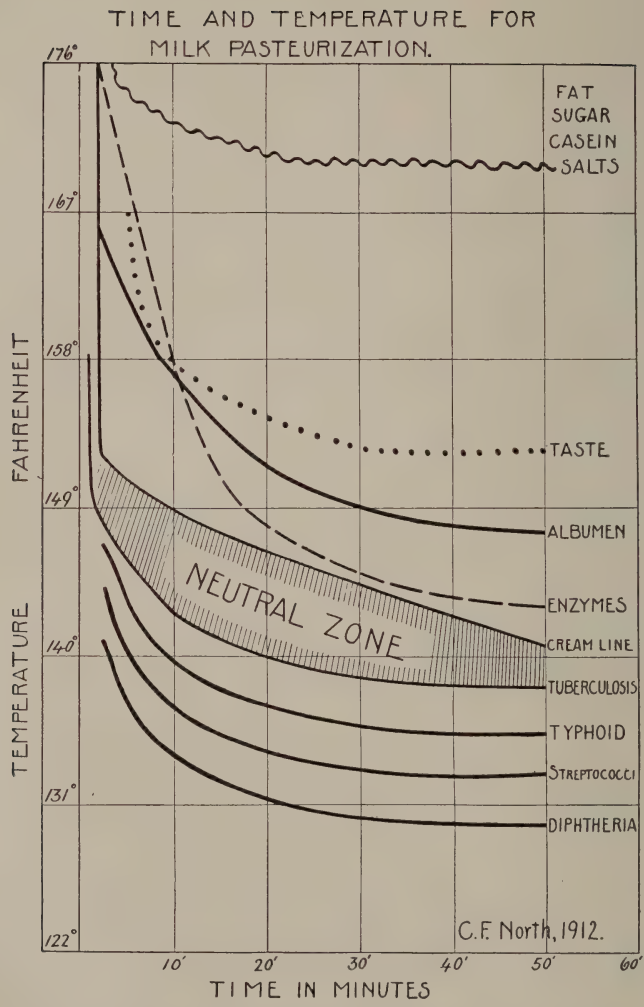
[1] Freeman, *Arch. Pediat.*, N. Y. (1898), vol. 15, p. 514.
[2] Freeman, *Jour. A. Med. Assn.*, vol. XLIX, Nov. 23, 1907, 21, p. 1740.
[3] Forster, *Hyg. Rundschau*, Berl. (1892), vol. 2 (20), 15. Okt., p. 872.
[4] Smith, Th., *J. Exper. Med.*, N. Y. (1899), vol. 4, p. 233.
[5] Oppenheimer, *Münch. med. Wchnschr.* (1899), vol. 46, p. 1462.
[6] Hippius, *Jahrb. f. Kinderh.* (1905), vol. 61, pp. 365–84.
[7] Bitter, *Ztschr. f. Hyg.*, Leipz. (1890), vol. 8, p. 255.
[8] Hesse, *Ztschr. f. Hyg.*, Leipz. (1900), vol. 34, p. 347.
[9] Russell and Hastings, 17 *Ann. Rep.*, Agric. Exper. St., Univ. Wis. (1900), p. 170.

The new milk regulations of the Department of Health of the city of New York regard only such milk or cream as pasteurized that has been subjected to a process in which the temperature and exposure conform to one of the following: —

No less than	158° F.	for at least 3 minutes
	155° F.	5
	152° F.	10
	148° F.	15
	145° F.	18
	140° F.	20

Rogers, Berg, and Davis[1] have recently made a series of experiments to determine the temperature at which cream should be pasteurized for butter-making. They found that when the cream was pasteurized at 66° C. (150° F.), and the butter made therefrom stored, such butter deteriorated. This was not evident in butter from cream pasteurized at a temperature of 71° C. (160° F.) or higher. At 82° C. (180° F.) the flavor of the butter was affected by the heat. They recommend, for the continuous pas-

[1] *United States Department of Agriculture, Bureau of Animal Industry, Circular* 189.



The neutral zone shows the time and temperature at which milk may be pasteurized with least disturbance to the cream line, enzymes, the albumin, the taste, etc. The time and temperature of the neutral zone is sufficient to kill such infections as tuberculosis, typhoid, streptococci, diphtheria, scarlet fever, " septic sore throat," etc.

teurization of sweet cream for butter-making, a temperature not lower than 74° C. (165° F.), nor higher than 80° C. (175° F.). These investigators further found that the destruction of the vegetative bacteria is uncertain at temperatures below 74° C. (165° F.). Peroxidase was destroyed at 77° C. (170° F.), catalase and lipase at 70° C. (158° F.). Galactase was much weakened by temperatures between 71° C. (160° F.) and 77° C. (170° F.), but was not destroyed at 93° C. (200° F.), the highest temperature employed.

In view of certain differences of opinion concerning the temperature and time of pasteurization the definition still lacks completeness; therefore the misconceptions and confusion concerning the use of the term "pasteurized milk" have added to the prejudice against the process. We should protest against a word which means a generality and again insist upon all pasteurized milk being properly labeled with the degree of heat, the period of time, and also the date on which it was subjected to the process.

The amount of pasteurized milk

Freeman tells us that it was about 1892 that the heating of the milk in the tenements of New York was widely adopted. So general had this become that the inspectors of the Rockefeller Institute for Medical Research, when recently seeking statistics concerning the effects of different sorts of milk on the health of babies, were unable to find sufficient infants fed on raw milk for the purposes of statistics. It is now (1910) estimated by Jordan that about fifty per cent of the total milk supply of Boston is pasteurized, namely, 126,565 quarts. In New York the figures are given at about twenty-five per cent. The amount of pasteurized milk in most of our large cities is showing a steady increase.

Pasteurization in bulk is practiced on a large scale in the creameries of Europe, particularly in Denmark and Germany. In Berlin and Copenhagen, especially, pasteurized

milk is in general use. In Denmark, in fact, paragraph 6 of the law of March 26, 1898, relating to measures for combating tuberculosis in cattle and hogs, requires that all skimmed milk and bottle milk from Danish dairies to be used for feeding animals must first be heated to about 85° C. This law went into effect June 1, 1899, was revised in 1903, and again in February 5, 1904, by requiring the products to be heated to 80° C. and adding, to the products requiring pasteurization, cream used for the manufacture of export butter. The same law requires that only such milk and buttermilk may be brought into Denmark as has been heated to at least 80° C.

In France the heating of milk is practiced by the wholesale dealers who supply Paris. A portion of the milk sold in certain of the larger cities in France, and the milk distributed from the infant depots (*gouttes de lait*) is also heated. Much of the cream destined for Paris is pasteurized.

Bacterial toxines

Much has been written concerning bacterial toxines, but when we sift the matter down to the bottom, we find a few definite facts which are comforting. It has commonly been said, especially by those who are opposed to pasteurization, that the heating does not destroy those toxines or chemical poisons which are produced by the growth and activity of bacteria in milk. Whether this is so or not must engage our attention.

The true toxines are soluble chemical substances of unknown composition and exceedingly poisonous in small amounts. They produce symptoms only after a definite period of incubation and are capable of inducing immunity as a result of the production of antitoxines. We are acquainted with very few true bacterial toxines. The best examples are the toxines of tetanus, diphtheria, and the poison produced by the *Bacillus botulinus*, or sausage poisoning. The true bacterial toxines are not resistant to

heat, that is, they are all rendered practically inert at a temperature of 60° C. Therefore, the ordinary temperatures used in pasteurization would also destroy the true toxines.

Are there any poisonous substances in milk that are not destroyed by heat? There may be such substances, but we do not know what they are. Experience teaches us that they must be exceedingly rare. It must further be remembered that if heat-resisting chemical poisons (so-called ptomaines) are present, they will be in the raw milk as well as in the pasteurized milk.

The effect of heat upon the harmful bacteria and their thermal death-points

Although it would appear to be a comparatively simple matter to determine precisely the temperature at which micro-organisms die, such work is in fact surrounded by many difficulties and pitfalls; different investigators have come to widely different results. Some of these discrepancies are only apparent and may be explained by the relation of time to temperature. The longer the time of exposure, the lower the temperature necessary to kill any organism. Differences in methods are also responsible for differences in results.

Among bacteria some strains or races are more resistant to heat than others. These differences, which correspond to similar known variations in all animal and vegetable species, must be taken into account.

Evaporation takes place so rapidly from exposed fluids that the surface layer may remain cooler than the body of the liquid. This is especially a matter of concern with milk, which sometimes forms a scum above 60° C., owing to rapid evaporation of the surface layer. This scum consists of coagulated albumins in which is enmeshed much fat. The bacteria entangled in this surface pellicle may escape the heat indicated by the thermometer in the deeper layers.

As a rule, bacteria are attenuated and lose their power to infect before they lose their ability to vegetate upon artificial culture media. It is, therefore, safe to assume that a micro-organism that will not grow in artificial media under favorable conditions is "dead." The tubercle bacillus is an exception to this rule, for reasons given further on.

The methods used in the tests which I have made from time to time were planned to imitate the actual conditions of pasteurization, so far as practicable, in laboratory experiments.

The test tubes in which the infected milk was heated were open to the air, and scum formation was disregarded in all instances, my object being to determine the thermal death-point against natural difficulties, so that the results might be applied with confidence to practical pasteurization.

Bacillus tuberculosis. Certain special difficulties are met with in determining the thermal death-point of the tubercle bacillus. This organism does not grow readily upon artificial media. The few experiments made to determine its thermal death-point by cultural methods have no significance, because its vegetability upon artificial media does not correspond to its power of growing in the animal organism. It is therefore necessary to inoculate animals in order to determine whether or not the tubercle bacillus is alive and virulent. Here again we meet with complications. Dead tubercle bacilli have a certain amount of pathogenic power and produce lesions, including tubercle formation, abscesses, and coagulation necrosis. However, while we lack a criterion to determine with precision the exact point when the tubercle bacillus dies, we are able by means of animal inoculations to determine just when the tubercle bacillus is so enfeebled that it is no longer able to infect. This, after all, is the important practical point.

In my own experiments, in order to avoid the confusion

resulting from the effects produced by dead tubercle bacilli, doubtful lesions were carried over into another animal.

From these experiments it is evident that the tubercle bacillus in milk loses its infective properties for guinea-pigs when heated to 60° C. and maintained at that temperature for twenty minutes, or to 65° C. for a much shorter time.

It should be remembered that the milk in these tests was very heavily infected with virulent cultures, indicated by the prompt deaths of the control animals. Milk would practically never contain such an enormous amount of infection under natural conditions. It is justifiable to assume that if 60° C. for twenty minutes is sufficient to destroy the infectiveness of such milk when injected into the peritoneal cavity of a guinea-pig, any ordinary market milk after such treatment would be safe for human use by the mouth so far as tubercle bacilli are concerned.

It is difficult, if not impossible, to briefly summarize the work of others upon the thermal death-point of the tubercle bacillus in milk. The following table (see page 202) necessarily leaves out many factors.

The tabular statement shows that my results agree with the work of Yersin, Bonhoff, Schroeder, Th. Smith, Russell and Hastings, Hesse, and Rosenau in that 60° for twenty minutes is sufficient to kill the tubercle bacillus.

The lesions produced by a large mass of dead tubercle bacilli may be distinguished by their extent rather than by their character. In doubtful cases secondary inoculation is the only trustworthy method of determining whether the bacilli are alive or dead. The tuberculin test does not differentiate between the live and dead tubercles. Three guinea-pigs out of eight having lesions produced by dead tubercle bacilli (killed at 100° C.) died as the result of the subcutaneous inoculation of two cubic centimetres tuberculin (O. T.).

TABLE SHOWING THE THERMAL DEATH-POINT OF THE TUBERCLE BACILLUS AS FOUND BY VARIOUS INVESTIGATORS

Investigator	Killed at —	Not killed at —
Martin, 1882		80°.
May, 1883	By cooking	
Sormani, 1884	Boiling, 5 minutes	90° for 10 minutes.
Schill and Fisher, 1884		100°.
Voelsch, 1887		100°, boiling twice.
Yersin, 1888	60°, 10 min. (—spores)..	
	60°, 10 min. (+ spores).	
Bitter, 1890	68°, 20 minutes	
Bang, 1891	70°, 5 min. (enfeebles).	
	60°, 5 min. (sometimes enfeebles)	
	80° (sometimes kills) ..	
	85° (always kills)	
Bonhoff, 1892	60°, 20 minutes	50°, 60 minutes.
Gancher and Ledeux-Lebard, 1892	60°, 5 min. (attenuates)	
	70°, 1 min. (kills)	
Forster, 1892	60°, 6 hours	55°, 3 hours.
	95°, momentary	60°, 45 minutes.
		80°, momentary.
De Man, 1893	55°, 4 hours	60°, 45 minutes.
	60°, 1 hour	
Schroeder, 1894	69°, 15 minutes	
Woodhead, 1895	50°, 15 hours	90°, (results contradictory).
	60°, 8 hours	
	60°, 45 minutes	
	70°, 45 minutes	
	70°, 2½ minutes	
Marshall, 1899	68°, 20 minutes	60°, 10 minutes.
Th. Smith, 1899	60°, 15 to 20 minutes	
Morgenroth, 1900	55°, 3 hours	70°, 10 minutes.
		100°, momentary.
Kobrak, 1900	50°, 4 hours	
Beck, 1900	100°, 3 hours	100°.
		80°, 30 minutes.
Galtier, 1900		85°, 6 minutes.
Russell and Hastings, 1900	60°, 20 minutes	
Herr, 1901	65°, 15 minutes	80°, 5 seconds.
Hesse, 1901	60°, 20 minutes	
Levy and Bruns, 1901	65°, 15 minutes	
Barthel and Stenström, '01		70°, 15 minutes.
Bang, 1902		60°, 15 minutes.
Tjaden, 1903	85°, 1 to 2 minutes	
Rullmann, 1903	65°, 30 minutes	60°, 20 minutes.
Barthel and Stenström, '04	80°, 1 min. (uncoag'd)...	80°, 1 min. (coagul'd).
Russell and Hastings, 1904	71°, 1 minute	
Zelenski, 1906		76°, 20 minutes.
Rosenau, 1907	60°, 20 minutes	

The typhoid bacillus. The evidence is plain that milk heated to 60° C. and maintained at that temperature for two minutes will kill the typhoid bacillus. The great majority of these organisms are killed by the time the temperature reaches 59° C., and few survive to 60° C.

The *diphtheria bacillus* succumbs at comparatively low temperatures. Oftentimes it fails to grow after heating to

55° C. Some occasionally survive until the milk reaches 60° C.

The *cholera vibrio* is similar to the diphtheria bacillus so far as its thermal death-point is concerned. It is usually destroyed when the milk reaches 55° C.; only once did it survive to 60° C. under the conditions of the experiments.

The *dysentery bacillus* is somewhat more resistant to heat than the typhoid bacillus. It sometimes withstands heating at 60° C. for five minutes. All are killed at 60° C. for ten minutes. However, the great majority of these micro-organisms are killed by the time the milk reaches 60° C.

So far as can be judged from the meagre evidence at hand, 60° C. for twenty minutes is more than sufficient to destroy the infective principle of *Malta fever* in milk. The *M. melitensis* is not destroyed at 55° C. for a short time; the great majority of these organisms die at 58°, and at 60° all are killed.

A temperature of 60° C. for twenty minutes is sufficient to destroy the virus of scarlet fever, streptococci, and other pathogenic organisms.

Milk heated to 60° C. and maintained at that temperature for twenty minutes may, therefore, be considered safe so far as conveying infection with the micro-organisms tested is concerned.

Chemical changes in milk produced by heat

The changes produced in milk by heat depend upon the degree of heat and the length of exposure. The exposure of milk to a temperature of 60° C. for a short time does not appreciably affect its chemical and physical properties. The boiling of milk, however, produces pronounced changes. These changes consist mainly of the following: —

Decomposition of the proteins, and other complex nitrogenous derivatives.

Diminution of the organic phosphorus.

Increase of inorganic phosphorus.

Precipitation of the calcium and magnesium salts and the greater part of the phosphates.

Expulsion of the greater part of the carbon dioxide.

Caramelization or burning of a certain portion of the milk sugar (lactose), causing the brownish color.

Partial disarrangement of the normal emulsion and coalescence of some of the fat globules.

Coagulation of the serum albumin, which begins at 75° C.

The casein is rendered less easy of coagulation by rennin and is more slowly and imperfectly acted upon by pepsin and pancreatin.

Boiling gives the milk a "cooked" taste.

The cream does not rise well, if at all.

When the milk reaches about 60° C., a scum forms on the surface which consists of —

Fatty matter	45.42
Casein and albuminoid	50.86
Ash	3.72

Milk heated in closed vessels does not form a pellicle even when the temperature reaches 100° or 110° C. Milk heated in the open air, after cooling forms a pellicle on the surface which renews itself if it is removed. It seems that this pellicle is due mainly to the drying of the upper layer of the liquid.

Heat kills the ferments in milk,[1] which according to some

[1] Hippius (*Deut. med. Woch.*, vol. 27, 1901, pp. 481, 502) states that the oxidizing ferments are able to withstand temperatures between 60° and 65° C. for a long time, but are destroyed after a short exposure to 76° C. The lipase, or fat-splitting ferment, withstands one hour's heating at 60° C., or 62° for a short time; is weakened at 63°, and destroyed at 64° C. The proteolytic ferment withstands one hour's heating at 60° or half an hour at 65° C. The amylase withstands one hour at 60° and is only destroyed at 75° C. See also Kastle and Roberts, article no. 10, p. 307, *Hyg. Lab. Bul.* no. 41, P. H. & M. H. S.

authors play a useful rôle in digestion and metabolism. We have no direct knowledge of the utility of these ferments. For the child to digest and assimilate cow's milk to advantage the complex albuminous substances must first be broken down by the processes of digestion into simpler products and again synthetized. In other words cow proteins must be converted into human proteins. In this process enzymes play an essential rôle. We know that the digestive tube contains ferments that dissolve and break up the complex proteins into simpler substances, but concerning the rearrangement of these simpler compounds into forms best suited for assimilation we have little definite knowledge. While ferments play an active part in both the breaking-down and the building-up processes, it remains for future investigation to determine what particular ferments are helpful in the latter process. It has been abundantly shown by laboratory work that the ferments in milk, or most of them, at least, can withstand a temperature ranging from 60° to 65° C. for some time without material injury. Between 65° and 70° most of these are weakened in their activity, and between 70° and 80° all of them are destroyed even after relatively short exposure. (Kastle.)

Raw milk shows the peroxidase reaction, whereas milk which has been heated for one hour at 70° C., or for shorter intervals at higher temperatures, does not exhibit this reaction. In this connection Kastle and Porch [1] have observed that on heating milk to 60° C. for 20 minutes, the peroxidase reaction of many specimens of milk is not only diminished but if anything somewhat intensified.

The following table (page 206) from Kastle and Roberts' article on "Chemistry of Milk" in Hygienic Laboratory Bulletin no. 41, p. 333, gives instructive data pertaining to the destruction by heating of enzymes in general.

[1] *Journal of Biological Chemistry*, vol. IV, 1908, pp. 301–20.

Name of ferment	Temperature at which destroyed (° C.)
Bromelin	Weakened at 70
Caroubinase	80, weakened at 70
Cystase	60
Dextrinase	75
Diastase (plant)	80
Diastase (saliva)	65–70, slowly at 58
Emulsin	70
Enterokinase	65 (slowly)
Invertase	70, very slowly at 45–50
Laccase	60–63
Lipase	72 (Hanriot) 65–70 (Kastle & Loevenhart)
Maltase	55
Myrosin	81–85
Oenoxydase	72
Papain	82.5
Pepsin	55–57
Rennin	70, neutral; 63, faintly acid
Trehalase	64
Trypsin	75–80
Thrombase	70 (Schmidt)
Tyrosinase	55
Urease	75–80

The heating of the milk produces a decomposition of the albuminoid matter, manifesting itself by the production of a little hydrogen sulphid. This gas may also be produced by the action of micro-organisms.

It is claimed that the heating of milk renders a part of the phosphates insoluble, and that this change favors rachitis in children artificially fed with it. On the other hand it appears to be the general opinion of physicians that rachitis is the result of defective alimentation, due to causes other than the changes in heated milk.

The heating of milk for half an hour at a temperature of 150° F. (65° C.) or over, has the effect of entirely preventing the rising of the cream or of delaying it very materially.

In normal milk the larger proportion of the fat droplets agglutinate into tiny globules or masses. At a temperature of 65° C. or above, these clusters are broken down and the globules are more homogeneously distributed throughout the fluid.

The cooked or scalded taste appears at about 70° C., and becomes more pronounced the higher the temperature. This is due perhaps to a decomposition of certain of the proteids in the milk. The loss of certain gases also alters the taste, so that milk heated in closed vessels has a much less pronounced flavor than if heated in open vessels.

The coagulation of milk depends upon several factors, among which are time, temperature, degree of acidity, quantity and solubility of the calcium salts, etc.

Milk curdles when it is heated to 130 or 150° C. It may also be coagulated by about twelve hours heating at 100° C.

The presence of acids favors coagulation of milk at or below the boiling-point, due to the fact that very small quantities of acid liberate the casinogen and render the calcium salts normally present in milk available for its coagulation.

Milk sometimes curdles in the process of pasteurization. This is due to the amount of acid and calcium salts which it contains. In order to avoid such accidents, Kastle advises that the only safe rule to follow is to determine the effect of heating on small samples of the milk in advance.

It has been observed that cooked milk coagulates with rennin more slowly than raw milk. This effect is noted often at temperatures of 80° to 90° C., but it has not been observed in milk heated to 60° for twenty minutes. The curd produced by rennin coagulation in cooked milk is softer, less tough, and more flocculent, than that produced by rennin coagulation in raw milk. This is believed to be an advantage favoring the digestibility of heated milk.

Home pasteurization

If pasteurization is to be done, theoretically the best place to do it is in the home; that is, it would be advisable to pasteurize milk just before it is used. The heating of milk to just the proper temperature and holding it there for just the proper period of time (say 60° C. for twenty minutes), and then cooling it rapidly, seems a very simple operation, but any one who will try it will find that it is not so easy as it seems, in that it requires an intelligent and careful manipulation and a due regard for the laws of physics.

With the possible exception of milk for infant feeding it is much easier and cheaper to pasteurize the milk in bulk under competent supervision, instead of leaving it to the usual carelessness of cooks who cannot be expected to master the technic nor appreciate the dangers. Imperfect pasteurization may be worse than none, for it gives a sense of false security and may even result in further contamination of the milk. If our drinking-water must be purified, experience teaches us that we cannot depend upon each individual householder to do it. Further, this retail purification is enormously expensive and a great waste of time when compared to centralized and supervised pasteurization.

The most practical home pasteurizer is that devised by Freeman. A number of experiments which I have made in the laboratory with this pasteurizer shows its efficiency.

The home pasteurizer devised by Mr. Nathan Straus[1]

[1] No discussion of the subject is complete without recognition of the debt we owe Mr. Nathan Straus for his early and persistent advocacy of pasteurization and the establishment of his infant's milk depots. Through his influence and philanthropy this movement has now spread to many cities of this country and abroad.

Mr. Emile Berliner of Washington has also for many years pointed out the dangers of raw milk and taught the wisdom of scalding milk.

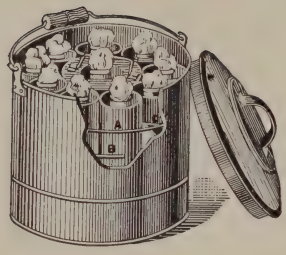


FIG. 1.

Showing the apparatus arranged for heating the milk before the pail is covered.

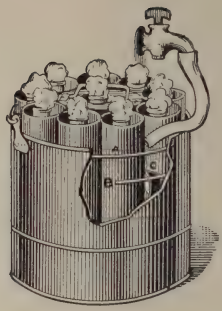


FIG. 2.

Showing the apparatus arranged for cooling the milk.

The apparatus consists of a pail for water and a receptacle for the bottles of milk.

The *pail* is a simple pail with a cover. Extending around the pail is a groove for indicating the level to which the pail is to be filled with water. Inside the pail are three supports (C) for holding the receptacle.

The *receptacle* for the bottles of milk consists of a number of hollow cylinders fastened together. Surrounding and binding together the group of cylinders is a wire (A). It is this wire (A) which rests on the support (C) when the milk is being heated (Fig. 1). Below the wire (A) are three short wires (B). These wires (B) rest on the supports (C) when the receptacle is raised for cooling (Fig. 2).

1. Fill the pail to the level of the groove with water, cover it and put it on the stove to boil, the receptacle for the bottles having been left out.

2. Fill the body of each bottle with milk or some modification of milk in proper proportion for feeding; stopper with a wad of cotton batting and put in a refrigerator. If all the bottles which the receptacle holds are not needed, fill the remaining cylinders with cold water. Each space in the receptacle must be filled.

3. When the water in the pail on the stove boils thoroughly, take the bottles of milk from the refrigerator and put them in the spaces for them in the receptacle.

4. Pour cold water into each of these spaces so as to surround the body of the bottle.

5. Take the pail of boiling water from the stove and put it on a table or mat. Do not put it on metal or stone. Be sure that the pail is still filled exactly to the level of the groove and that the water is boiling vigorously.

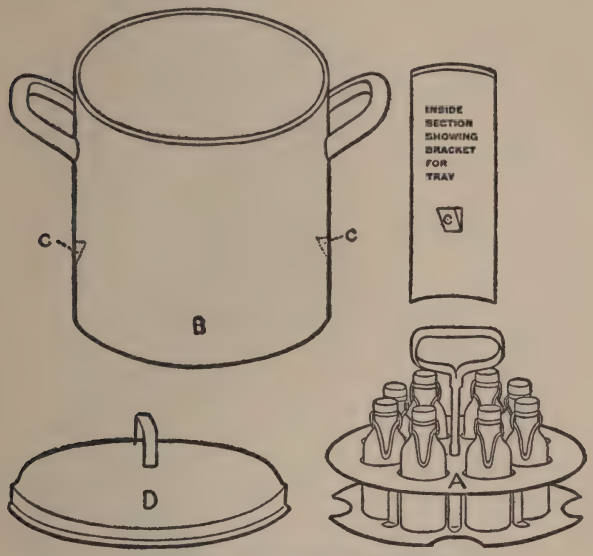
6. Set the receptacle containing the bottles of milk into the pail of boiling water, so that the wire (A) will rest on the support (C), cover the pail quickly and let it stand forty-five minutes. During this period the pail must not be on the stove and the cover must not be removed.

7. Now uncover the pail and lift the receptacle and turn it so that the wire (B) will rest on the support (C), thus elevating the top of the receptacle above that of the pail. Put the pail containing the receptacle elevated in this manner in a basin, under a faucet to which a rubber pipe may be attached connecting it with the pail (Fig. 2). The water will overflow from the pail into the basin. Or the pail may be stood under a pump, fresh cold water being pumped into it every few minutes.

The above described method of cooling is the best. When, however, it is not possible to cool the milk in this way, the cooling may be accomplished by placing the receptacle containing the bottles of milk in iced water, or by simply standing the bottles on wood in a refrigerator.

FREEMAN'S PASTEURIZER

shown in the accompanying illustration is a modification of the Freeman pasteurizer.



STRAUS HOME PASTEURIZER

In the Straus pasteurizer the cups in which the bottles rest are omitted, thus making it simpler and cheaper. He gives the following directions for the manufacture of his home pasteurizer: —

	Size I Eight 3-ounce bottles	Size II Eight 6-ounce bottles	Size III Six pint bottles
Height of pan	10 1-8 in.	10 1-8 in.	14 3-4 in.
Diameter of pan	10 1-8 in.	10 1-8 in.	10 1-8 in.
Distance of top of bracket from bottom of pan . .	3 7-16 in.	4 5-8 in.	6 1-8 in.
Amount of water . . .	5 quarts	6 3-4 qts.	9 quarts

The following directions are abstracted from Mr. Straus's instructions for the use of his home pasteurizer: —

Emphasis is laid on the fact that only fresh, clean milk, which has been kept cold, should be used.

After the bottles have been thoroughly cleaned they are placed in the tray (A) and filled to the neck. Then put on the corks or patented stoppers without fastening them tightly.

The pot (B) is now placed on the wooden surface of the table or floor and filled to the supports (C) with boiling water.

Place the tray (A) with filled bottles into the pot (B) so that the bottom of the tray rests on the supports (C), and put cover (D) on quickly.

After the bottles have been warmed up by the steam for five minutes, remove the cover quickly, turn the tray so that it drops into the water, replace the cover immediately. This manipulation is to be made as rapidly as possible to avoid loss of heat. Thus it remains for twenty-five minutes.

Now take the tray out of the water and fasten the corks or stoppers airtight. Cool the bottles with cold water and ice as quickly as possible, and keep them at this low temperature until cold.

Use the milk from the bottles and do not pour it into another vessel.

The milk must not be used for children later than twenty-four hours after pasteurization.

The attempt is frequently made to pasteurize milk in the home by simply placing the bottle of milk as it is received in a pot of water. The water is then brought to the boiling-point for a variable length of time and finally cooled. At first glance this appears to be an entirely satisfactory procedure, but in some experiments upon the subject I have shown that the depth of the water in which the bottle is immersed markedly affects the results. The neck of the bottle must always project above the water, and unless the pot has a lid the upper layers of the milk may therefore escape heating, especially if the contents have not been well shaken up, for the thick cream prevents circulation of the liquid. Therefore, contrary to what might be expected from the physics of fluids, the top layers of the milk in the

bottle are sometimes not as hot as the bottom, or require a much longer time to heat up.

Commercial pasteurization

Pasteurization of milk on a commercial scale often leaves much to be desired. But although it is not always thoroughly carried out, it is by no means a fraud, as we are sometimes told. With a little sanitary supervision on the part of the health officer and education on the part of those in charge of the process, it may be made efficient. It is much easier to pasteurize milk on a large scale than on a small scale in the household.

Commercial pasteurizers at first were popular with dairymen, not because of the public health interest, but on account of the economic advantages in improving the keeping qualities of the milk. It is estimated that the expense of a pasteurizer would pay for itself in the course of about a year. This estimate is based mainly on the saving of losses from sour milk. The cost of pasteurization in bulk varies from about one tenth to one half of a cent a quart.

There are three ways in which milk may be pasteurized commercially: —

(1) By the flash method, which is sometimes improperly called commercial pasteurization.

(2) By the holding method, which is also known as perfect pasteurization.

(3) Pasteurization in the bottle or final container.

Each of these requires consideration. The flash method, in which the milk is momentarily heated to 70° or 80° and then at once chilled, cannot be depended upon to kill the tubercle bacillus, and is known to give irregular and unreliable results. It is difficult to be sure that every particle of the milk is heated to the desired temperature; in fact, it is quite sure that some of the milk escapes, and the results, therefore, are irregular and unreliable. Flash pasteuriza-

tion should therefore not be countenanced by health authorities.

Pasteurization with holding devices, sometimes called perfect pasteurization, is the method most in vogue, and, when properly carried out, is entirely satisfactory. The pasteurized milk must at once be cooled and filled into sterilized bottles by machinery. Every possible precaution must be exercised to prevent contamination after the milk has been heated.

The milk is first heated to the desired temperature and is then held in bulk at this temperature for the required length of time. With a good holding device there is not a loophole for any harmful bacteria to escape destruction. Two forms of holding devices are used by dairymen. One is the Wilmer pattern, which consists of a circular disk divided into segments. In each segment is a container to hold the milk. The containers are filled in turn, and the apparatus may be so timed that it requires just twenty, thirty, or forty-five minutes during which the milk is held in any particular segment. The other holding device is known as the Park tanks. They consist simply of large cylindrical tanks into which the heated milk is carefully poured and held for a given length of time. Milk in a large cylindrical tank will gradually cool, and theoretically the cooler milk should remain on the bottom while the warmer oncoming milk should stay on top. If this simple law of physics were not disturbed by counter-currents, irregularities in the temperature of the oncoming milk, and other reasons, the Park tank could be used as a continuous holding device, but on account of the irregularities in the temperature of the heated milk, cross-currents, etc., it is necessary to have three or four such tanks, the milk flowing from one to the other in succession in order to be sure that no particle of the milk escapes before the proper time.

In order to satisfy public health requirements, pasteurizers must be efficient in operation, permitting a definite

quantity of milk to be heated to a definite temperature for a definite time (Russell). They must be easy to control, the milk must be heated uniformly throughout, the apparatus must be simple in construction, easily cleaned, economical in use, and arranged to safeguard against re-infection of the milk. Further, an efficient pasteurizer must not heat any part of the milk appreciably higher than the temperature desired. Finally, provision must be made for rapid cooling.

Given an apparatus of proper construction, more depends upon the intelligence and care with which it is run than upon the machine. No pasteurizer is automatic, no pasteurizer is fool-proof. For instance, I have found milk pasteurized in a standard machine containing many more bacteria after the process than before. This was not the fault of the machine, but due to negligence and uncleanliness. It is better to depend upon mechanical thermoregulation than to attempt to regulate the degree of heat to which the milk is subjected by hand. Pasteurizers should all be provided with automatic thermometers which record upon a revolving dial just what takes place. This automatic instrument should be under the lock and seal of the health officer.

The best way to pasteurize milk is in the final container. This has the advantage of eliminating the possibility of re-infection. For a long time it was said that the pasteurization of milk in the bottle was not a commercial possibility. The difficulties, however, have been overcome by brewers, who pasteurize beer in the bottles, and recently a progressive dairyman of Boston has introduced a method of pasteurizing milk in bottles which is entirely satisfactory from every standpoint. The bottles are stoppered with a crown-cork and seal and are then immersed entirely in a water bath, which is gradually heated until the temperature of the milk within the bottles registers 148° F. This temperature is maintained for thirty minutes, when the water

is gradually, then rapidly, cooled and the bottles placed on ice. The consumer, therefore, receives a bottle of milk which he can depend upon as being entirely free of infection. In my judgment this method furnishes the safest milk package that has yet been devised.

The Loew pasteurizer, long used by brewers, is now being introduced into the milk industry for heating milk in the bottles. There are two forms of these machines — one is continuous and the other intermittent. The principle in both is alike. The warm water is pumped so that it is showered over the bottles. The temperature of the water is regulated automatically and the time of exposure can also be controlled with precision. The method, therefore, has much to commend itself. Milk thus pasteurized in a sealed bottle is " the perfection of the art."

Pasteurized milk in relation to infant feeding

Entirely too much stress has been placed upon the effects of pasteurized milk upon infants. The great emphasis laid upon this minor point has led to an exaggerated notion of its importance. The question of unfit milk in relation to the adult and the growing child has been correspondingly neglected. It has, in fact, almost been disregarded. Viewed broadly, we find that infected milk plays proportionately almost, if not as much, havoc among adults and children as it does among infants.

This is not a place for the discussion of infant feeding, but certain facts stand out clearly and demand emphasis: —

Babies should have mother's milk. There is no adequate substitute. "Prepare cow's milk as we may, we cannot shut our eyes to the fact that it is out of the question to anticipate such good results from artificial feeding as from breast feeding. It is well known that the lowest death rate for the first year of life is shown among those infants who are fed on human breast milk." If, for any reason, mother's milk is not available, babies are entitled to the very best and fresh-

est cow's milk that can be obtained. Whether this is to be modified, pasteurized, or otherwise treated is a question for the doctor to decide in each individual case.

For adults and for children over two years of age there can be no more objection to the heating of milk than there is to the broiling of a beefsteak. The heating of the milk does not materially change its nutritive or digestive value; in fact, milk heated to a temperature just sufficient to kill the harmful bacteria cannot be distinguished from raw milk by its flavor or appearance, or by laboratory tests.

Babies who cannot get the best quality of cow's milk should receive protection through pasteurization, especially in the summer-time.

The relation of dirty milk to infant mortality demands separate consideration.

Park and Holt [1] studied groups of infants in the tenement houses and institutions in New York for periods of about three months in the summers of two years (1902–03). This work is the most important evidence we have on the subject, for it combines careful clinical observation with laboratory studies. Although the number of cases was comparatively small, the results obtained were almost identical during the two summers, and indicate that even fairly pure milk, when given raw in hot weather, causes illness in a much larger percentage of cases than the same milk given after pasteurization. A considerable percentage of infants, however, did apparently as well on raw as on pasteurized milk. Park and Holt include in part: —

The number of bacteria which may accumulate before milk becomes noticeably harmful to the average infant in summer differs with the nature of the bacteria present, the age of the milk, and the temperature at which it has been kept. When milk is

[1] Park, William H., and Holt, L. Emmett, "Report upon the results with different kinds of pure and impure milk in infant feeding in tenement houses and institutions of New York City: A clinical and bacteriological study," *Medical News*, vol. 83, 1903, p. 1066.

taken raw the fewer bacteria present the better are the results. Of the usual varieties, over 1,000,000 bacteria per cubic centimetre are certainly deleterious to the average infant. However, many infants take such milk without apparently harmful results. Heat above 170° F. (77° C.) not only destroys most of the bacteria present, but apparently some of their poisonous products. No harm from the bacteria previously existing in recently heated milk was noticed in these observations, unless they had amounted to many millions, but in such numbers they were decidedly deleterious.

When milk of average quality was fed sterilized and raw, those infants who received milk previously heated did on the average much better in warm weather than those who received it raw. The difference was so quickly manifest and so marked that there could be no mistaking the meaning of the results.

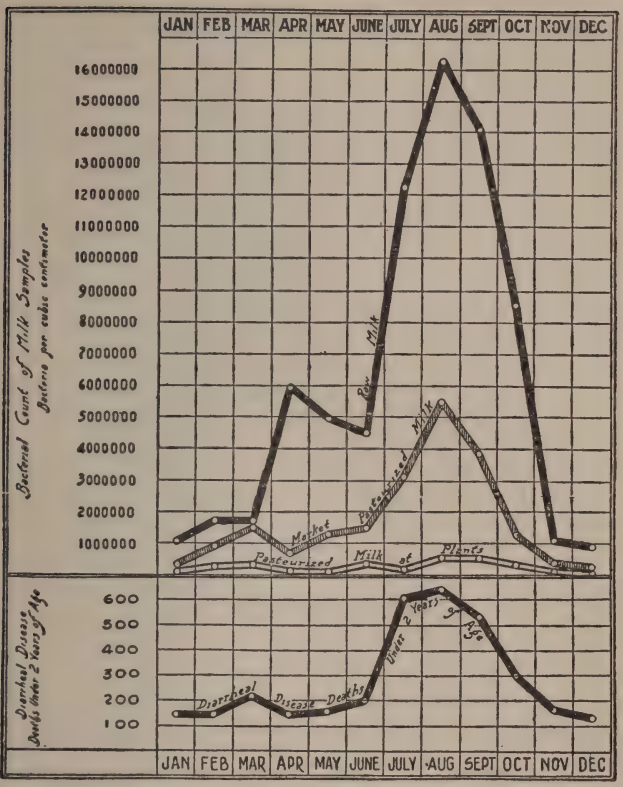
A few cases of acute indigestion were seen immediately following the use of pasteurized milk more than thirty-six hours old. Samples of such milk were found to contain more than 100,000,000 bacteria per cubic centimetre, mostly spore-bearing varieties. The deleterious effects, though striking, were not serious or lasting.

After the first twelve months of life, infants are less and less affected by the bacteria in milk derived from healthy cattle. According to these observations, when the milk had been kept cool the bacteria did not appear to injure the children over three years of age at any season of the year, unless in very great excess.

The general practice of heating milk, which has now become a custom among the tenement population of New York, is undoubtedly a large factor in the lessened infant mortality during the hot months.

Only the purest milk should be taken raw, especially in summer.

Physicians who have had large experience in the care and feeding of infants have a prejudice against the use of heated milk for prolonged periods. While it is admitted that the use of heated milk greatly diminishes the amount and seriousness of infantile diarrhœas, it has been stated that while the children at first do well they may become



BACTERIA FOUND IN RAW AND PASTEURIZED MILK

Monthly Average of Bacterial Counts, 1910, compared with Monthly Deaths among Children from Diarrheal Diseases. (From Chicago Commissioner of Health.)

flabby and anæmic and the subjects of scurvy. It is probably not the heating, but some other factor in the milk that induces scurvy.

We have the published testimony of a large number of physicians to the effect that the use of pasteurized milk produces no harmful effects that may be attributed to the heating. But when all is said and done, the pasteurization

of milk for infant feeding can neither be recommended nor discountenanced as a general proposition. The saying that "one man's meat is another man's poison" applies with special significance to the artificial feeding of infants. The general pasteurization of all milk used for the nourishing of infants would be as irrational as the general use of one formula. Each infant is a law unto itself, and whether it is to receive heated or unheated milk must depend entirely upon the conditions, especially the season of the year and the quality of the milk available.

Scurvy occurs in children fed both upon pasteurized and unpasteurized milk; it may even occur in breast-fed infants. Scurvy is at most a comparatively rare disease. As there are countries where, despite sterilization, scurvy practically never occurs, the cooking of the milk cannot be the only cause of this disease. It is not a new disease, but was described in infants for the first time only a decade ago. Even at the present time the disease is often not recognized by clinicians. Formerly the condition was called "acute rickets" (Möller). In Germany we are told the disease is either exceedingly rare or not recognized. For a long time the French claimed that the disease did not exist among them, but during the past two or three years there have been occasional reports of isolated cases (Netter).

The disease was first studied by English clinicians, and we are especially indebted to Barlow, who, after a study of eleven cases with post-mortem results of two, showed the essential features of the disease and gave it the name of scurvy. It is often spoken of as Barlow's disease,[1] or the Möller[2]-Barlow disease.

We do not know whether scurvy has increased greatly during the past twenty years, or whether our more precise

[1] Barlow, *Med. and Chir. Transactions*, London, vol. 66, p. 83.

[2] Möller, Akute Rachitis, *Königsberg. med. Jahrb.*, Bd. I (59), and Bd. III (62).

knowledge of the disease has made this apparent. Those who believe the disease is increasing attribute this fact to the use of dried proprietary infant foods and the increasing use of heated milk.

The proper treatment of infantile scurvy gives almost miraculous results. "Within a few hours a pitiable, suffering little paralytic is transformed to a contented baby waving its arms and legs in the sheer joy of living." This may be simply brought about by the use of fresh milk, fruit juices (orange, grape, or pineapple), beef juice, egg albumen, or puree of potato, according to the child's digestive capacity. Scurvy is thus not only readily preventable, but amenable to treatment, and it would seem that those who have to choose between the use of a doubtful milk with its serious consequences, and the remote possibility of scurvy as a result of pasteurization, should not hesitate long in the choice.

I have made a careful compilation from the literature of the results of raising children upon heated milk, and find hundreds of instances recorded, especially by French observers, to the effect that children flourish well upon heated cow's milk and without the production of scurvy. But in view of the fact that scurvy is either rare or not recognized in France we must examine these figures critically.

Some of this evidence follows:

Variot [1] in a recent communication sums up his experience with the use of heated milk for infant feeding as follows: —

At the dispensary of La Goutte de Lait de Belleville, which I have directed since 1892, we have distributed for twelve years in the poorest quarters of Paris about four hundred thousand bottles of sterilized milk to more than three thousand in-

[1] Variot, M. G., "Valeur nutritive du lait de vache stérilisé à 108° pour l'allaitement artificiel." *Comp. rend. des séances de l'Acad. d. Sci.*, vol. 139, 1904, p. 1002.

fants of the working class deprived of their mother's milk. With my collaborateurs, MM. Drs. Dufestel, Lazard, and Roger, we have made a study of the artificial feeding with sterilized milk, and the results of our experiments are so decisive, each case controlled by weight, and an examination of the organs and functions, that we think our results merit publication.

The milk received from farmers in the country is heated to 108° C. before transportation in the bottles of half a litre, stoppered with cork and the medical seal. This milk keeps several days without alteration, even during the greatest heat of summer. It is delivered daily at the Belleville dispensary to one hundred to one hundred and fifty infants. Every week or oftener if necessary the infants are weighed and inspected with care, records of which are kept. The following are some of the conclusions of the results of twelve years' experience: —

1. The milk sterilized at 108° C. preserves all of its nutritive value. It is not inferior to milk pasteurized at 80° C. or with heating at 100° C. in the apparatus of Soxhlet.

2. The destruction by the heating of the enzymes, the slight alteration of the lactose, the doubtful precipitation of the citrate of calcium, or the alteration of the lecithins does not affect its assimilability in an appreciable manner. Not one case of infantile scurvy has been observed by the dispensary.

3. Thanks to this sterilized milk we have been able to raise not only healthy infants, but also atrophic infants, retarded in their development as the result of gastro-intestinal troubles.

4. Rachitis did not develop in any of the infants.

5. In three thousand infants of the poorest class about three or four per cent showed themselves incapable of using sterilized milk.

6. Constipation and anæmia were not rare among the infants raised by this method. On the other hand the summer diarrhœas were markedly attenuated in severity.[1]

Berlioz reports favorable results from the use of sterilized milk. He believes that with such milk we are capable

[1] Budin, M. P., "Sur le lait stérilisé," *Bull. de l'Acad. de méd.*, 3me sér., vol. 37, 1897, p. 685.

of enormously reducing infant mortality. From 1894 to 1897 he distributed sterilized milk to the poor of Grenoble during the months of July, August, and September. It was sterilized in an autoclave at 110° C. for half an hour in bottles containing 200 to 250 cubic centimetres.

The use of this milk gave the following death rates: —

Year	(A) Children fed on milk not sterilized (per 1000)	(B) Children fed on sterilized milk (per 1000)
1894	66.8	25.6
1895	86.9	42.2
1896	54.0	16.1
Average	69.3	27.9

The difference in favor of sterilized milk is much more striking than the figures indicate, for Class A includes bottle- and breast-fed children, while Class B includes only bottle-fed children. Further, the first figures are compiled from children of the better class, while the latter are drawn from children of the poorer classes.

Carel,[1] from observations upon infants of the working classes in Paris, recommends the use of sterilized milk from the time of weaning. He believes further that the use of sterilized milk has brought about a reduction in the dangers to infants to a minimum. In infants of normal weight and good health, nourished with sterilized milk, the dentition proceeds normally and the mortality from gastro-enteritis is nil.

From a comparison of two series of observations of infants coming from families of the same social conditions, living in the same quarter, and of whom the mothers had received the same advice, there occurred 31.8 per cent of rachitis among those nourished with ordinary milk (210 observations). The proportion of rachitis in 373 infants

[1] Carel, Armand, *Le lait stérilisé*. Paris, Thèses, 1902–03.

who received sterilized milk was only 15 per cent. None of the 373 infants given sterilized milk presented any symptoms of infantile scurvy (Barlow's disease).

Budin and Chavane,[1] 1894, reported 15 successful cases in 1892 and 1893 of infants fed upon milk sterilized at 100° C. in a water bath and used within twenty-four hours. They give in detail the increase in weight and the condition of each infant.

Maygrier,[2] 1901, states that of 590 infants who received sterilized milk from 1878 to 1901 not one died of diarrhœa. Much similar testimony to the same effect could be brought forward.

While the evidence is clear that many children are successfully raised upon milk heated even above the boiling-point, on the other hand we have a number of cases of scurvy following the use of heated milk, the condition ceasing with the use of raw milk. Of the 379 cases of scurvy brought together in the report of the American Pediatric Society in 1898, sterilized milk was the previous diet of 107.

Every physician knows from observation that some children do very well upon cooked milk. It is also generally known that it is often only necessary to correct the general dietary, to prevent overfeeding, and to correct the formula, in order to convert an apparently bad milk which is not agreeing with an infant into a good food. Often at the same time the heating of the milk is discontinued and the good results of the change are credited to the use of raw milk. Thiemich[3] found that infants, as well as other animals, throve best on the milk of their own species, but

[1] Budin, P., and Chavane, A., "De l'emploi, pour les nourrissons, du lait stérilisé à 100 degrés au bain-marie," *Bull. de Acad. méd.*, 3me sér., vol. 32, 1894, p. 67.

[2] Maygrier, "La consultation de nourrissons à la Charité, de 1898 à 1901," *Obstétrique*, vol. 6, 1901.

[3] According to studies by Dr. Janet E. Lane-Claypon. Reports to the Local Government Board (England) on Public Health and Medical Subjects, new series, no. 63.

that boiling the milk made practically no difference. It was formerly thought that when boiled milk of a foreign species was fed to infants, owing to the difference in the composition of the milk the boiling would have a more appreciable effect. This, however, Thiemich found not to be the case, which is also the experience of Finkelstein. Dr. Lane-Claypon studied the records of Ballin in Berlin among the children of the working class, one series being breast-fed and the other fed on the milk from municipal dairies, which contained 3 per cent of fat and from 20,000 to 30,000 bacteria per cc., produced and handled by careful methods. It was found that the breast-fed children did not have so great a physiologic drop in weight immediately after birth as did those artificially fed on boiled cow's milk. These infants fed on boiled cow's milk lost considerably more weight in the early days, but by the end of the two hundred and thirtieth day the difference was no longer present, and no difference was noted by the end of the first year, except possibly a slight variation in favor of the boiled milk. At the end of twelve months there was no greater percentage of rickets in the babies fed on boiled milk than in the breast-fed infants.

The results of animal experiments are somewhat contradictory and rather unsatisfactory. Observation upon infants, however, gives us definite results. Finkelstein, for instance, has shown that infants evidently do worse with cooked woman's milk than with raw milk. These experiments correspond entirely with similar experiments made with cow's milk upon calves. Finkelstein next made the experiment of feeding cooked and uncooked cow's milk to children. He used the best milk obtainable in Berlin, and was careful to use the same milk in both cases. The additions, dilutions, and other conditions were precisely the same. The only factor which varied was that in one instance the milk was cooked and the other raw. A study of these parallel cases does not show any essential differ-

ence so far as nutrition is concerned between those receiving the raw milk and those receiving the cooked milk.

Finkelstein tells us that similar experiments made in Stockholm, but continued over a longer time, viz., three years, confirmed his observations and failed to show any difference between the two methods.

So far as other metabolism experiments on infants are concerned, they likewise practically all point to the conclusion that raw milk has no advantage over cooked milk. This is especially evident with respect to the organic constituents of milk. So far as the metabolism of the mineral substances is concerned the evidence is somewhat contradictory. Thus, Mueller and Cronheim found the calcium balance to favor raw milk.[1] These results have not been confirmed by the work of others.

Krasnogorky found that iron is taken up more readily from cooked than from raw milk.

So far as we are able to conclude from the evidence at hand upon metabolism experiments, raw milk certainly has no advantages over cooked milk.

When we consider that we know practically nothing of the essential nature of scurvy we must be cautious in considering the connection between pasteurization and scurvy as cause and effect. Rotch,[2] for instance, says: —

In those cases where scorbutus has apparently occurred in infants who were being fed on milk heated to 212°, it may have been some other quality in the milk which produced the scorbutus, and that either the percentages which the infant has been fed upon are not those which are adapted to and fitted to that especial infant or that it is an exceedingly dirty milk which they have been boiling at 212°, and which necessarily does not become sterile milk in the meaning of infecting the individual.

[1] Finkelstein, H., "Die rohe Milch in der Säulingsernährung," *Therap. Monatsh.*, vol. 21, October, 1907, p. 508.

[2] Rotch, Thomas Morgan, "The Pasteurization of Milk for Public Sale," *Am. Journ. Pub. Hyg.*, vol. 17, May, 1907, p. 181.

The unsatisfactory state of our knowledge upon this subject is evident from the following views recently expressed:

Rummell[1] doubts the relationship between the Mueller-Barlow's disease and sterilized milk. The cause of this disease, despite the great literature upon it, is entirely unknown. The fact that the occurrence of infantile scurvy varies so much in different regions leads one to suppose that perhaps it has some relation to the food of the cow rather than to the heating of the milk. That the disease seems to be brought about sometimes by high-grade sterilization of the milk, in an analogous way to scurvy in adults, seems probable. Animal experiments have been very contradictory and have not yet done much to clear up the situation.

Koeppen[2] looks upon scurvy as an auto-intoxication brought about by intestinal putrefaction, which process is favored in children artificially raised.

Recent evidence points to the fact that scurvy may be brought about by lack of the inorganic salts of alkaline bases, especially potassium, in the infant's dietary. This, combined with the injurious effects of a high percentage of fat in the food, may bring about serious disturbances of digestion and metabolism, favoring the production of the scorbutic condition. If this view is correct it entirely eliminates the heating of the milk as an etiologic factor.

The objections to pasteurization: Résumé

Pasteurization saves lives and prevents sickness. Weighing against this great merit we have certain disadvantages connected with the heating of milk. That there are two sides to the question may be judged from the fact that those who give the matter careful consideration come

[1] Rummell, O., "Sterilisierte Milch?" *Deut. Praxis*, vol. 13, 1904, pp. 201–07.

[2] Koeppen, "Zur Möller-Barlow'schen Krankheit," *Jahrb. f. Kinderheilk.*, Bd. 44, 1897.

to diametrically opposite conclusions. From a theoretical standpoint some believe pasteurization to be an unsatisfactory and very feeble way out of a very difficult situation. From a practical standpoint others find pasteurization our only practical safeguard, at least until the general supply consists of good, clean, fresh, safe milk.

One of the chief objections to pasteurization is that it promotes carelessness and discourages the efforts to produce clean milk. It is believed that the general adoption of pasteurization will set back the clean milk movement at the source of supply and even encourage dirty habits. It will cause the farmer and those who handle the milk to believe that it is unnecessary to be quite so particular, for the dirt that gets into the milk is going to be cooked and made harmless. However, it is not proposed that pasteurization shall take the place of inspection and improvements in dairy methods. Even though pasteurization is adopted it does not mean that the health officer should relax his vigilance, or cease inspection and other means to raise the general quality of the milk. Even though milk is to be pasteurized it does not mean that all milk should be accepted for pasteurization. No milk should be pasteurized that does not comply with certain reasonable chemical and bacteriological standards. To insure this end the health officer must have authority to prevent the sale and use of bad milk, whether or not pasteurization is practiced.

The practical *versus* the theoretical side of this question may well be illustrated by the attitude of an eminent sanitarian in New York who, in his writings and public addresses, discourages pasteurization because theoretically it does not reach the source of the evil and because it is not the ideal. However, when this same sanitarian is consulted by a large contractor who handles many thousands of quarts of miscellaneous milk a day, he is confronted by a condition, not a theory, and advises pasteurization!

Pasteurization has often been accused of possessing the great disadvantage of producing scurvy and rickets. There is certainly no evidence to show that low temperature pasteurization, such as is now recommended, ever in itself induces scurvy. Hundreds of thousands of children have been raised upon heated milk without the production of this disease, which is comparatively rare, especially in such countries as Germany and France where artificial feeding with heated milk is most popular. Scurvy is readily preventable and amenable to treatment. Rickets results from defective alimentation and improper hygiene that cannot be laid at the doors of pasteurization.

One of the great objections to the pasteurization of milk is that it devitalizes it. If milk contains "life," it has probbably lost the last vestige of it after it is from twenty-four to forty-eight hours old and kept under such conditions that it contains myriads of bacteria. Ordinary market milk is dead and partly decomposed before it reaches the consumer. It has been shown that heating milk to 60° C. for twenty minutes, while it kills the dangerous bacteria, does not seriously affect the enzymes, and these ferments are the nearest approach to life with which we are familiar in milk. In other words, pasteurization does not devitalize milk any more than cooking devitalizes meat, vegetables, or cereals.

Another objection frequently urged against pasteurization is that some of the poisonous toxines are not killed at the temperatures used. We do not even know the nature of these poisonous products in milk, much less their thermal death-points. The true bacterial toxines are all rendered inactive by heating to a temperature of 60° C. for twenty minutes. Further, it must be remembered that if milk contains chemical poisons not destroyed by the heat of pasteurization it will contain these same poisons if the milk were consumed raw! In fact, the heating of the milk prevents the further formation of such injurious substances.

The objection frequently raised against pasteurization is that it destroys nature's danger signal; that is, it destroys the lactic-acid-producing bacteria; and it is said that pasteurized milk, therefore, does not sour normally, but turns putrid. In other words, putrefaction takes place instead of fermentation. This would be interesting if true. But recent experiments and observation have shown that milk properly pasteurized sours normally just as raw milk does. In other words, there are heat-resisting lactic-acid organisms which survive the temperatures now recommended.

It is sometimes said that the heat destroys great numbers of bacteria in milk and thus conceals the evidence of dirt. As a matter of fact, quite the contrary may be the case, for the heat of pasteurization kills mainly the bacteria that come from the udder, the teats, or the hands of the milker, while most of the resisting spores come from the dirt, dust, cow manure, and survive the heat of pasteurization.

Further, it is said that we must not meddle with nature: that pasteurization is an artificial expedient, and that if nature intended milk to be cooked she would have cooked it for us. Nature never intended milk to be collected, transported, and fed to young mammalian animals of another species one or two days after it leaves the mammary gland. Even when fresh, the milk of one species is not well suited to the needs of the young of another species. In the artificial feeding of infants with cow's milk we are meddling with nature. When artificial feeding is necessary we must endeavor to obtain fresh, clean, pure milk. If this is not possible the milk should be purified, especially in hot weather.

Pasteurization of all the milk supply of a community may not be desirable. The certified milk and the special milk free from contamination may not need it. Certain invalids and babies may require raw milk. Each infant is a law unto itself, but the general public should be protected

against the old, dirty and uncared-for milk which forms the bulk of the supply of large cities. Theoretically pasteurization should not be necessary. Practically we find it forced upon us.

Summary

Pasteurization simply means parboiling.

The heat kills the harmful germs that too often are found in milk, such as those of tuberculosis, typhoid, diphtheria, scarlet fever, sore throat, and the summer complaints of infants.

Pasteurization has only one object — to destroy these germs in milk.

Pasteurization is not the ideal, but only a temporary expedient.

Pasteurization is the simplest, cheapest, and least objectionable method of rendering infected milk safe.

There can be no more objection to pasteurized milk for the use of adults and children over two years of age than there can be to the broiling of a beefsteak.

Babies should have mother's milk. There is no adequate substitute.

If mother's milk is not available babies are entitled to the very best and freshest cow's milk that can be obtained. Whether such baby's milk is to be modified, pasteurized, or otherwise treated is a question for the doctor to decide in each individual case.

Pasteurized milk is just as digestible as raw milk.

Pasteurized milk is just as nutritious as raw milk.

The correct temperature to heat the milk is 140° F., that is, 60° C., for twenty minutes. Higher heat or longer time is unnecessary. Anything less is not effective, and gives a false sense of security.

Pasteurization should never be used as a redemption process.

Pasteurization should never be used as a preservative.

Pasteurization cannot atone for filth.

Pasteurization cannot make good milk out of bad milk. All that pasteurization does is to destroy certain of the dangers in milk.

All milk that cannot be certified as clean, fresh, and safe, should be pasteurized — raw milk may be dangerous milk.

Pasteurized milk should be labeled with the time, temperature, and date.

Pasteurization is too important a health measure to leave to the caprice of the individual.

Pasteurization should always be done under the supervision of the health officer.

Pure milk is better than a purified milk — but until the milk is safe our only protection is through pasteurization.

Pasteurization saves lives and prevents sickness.

CHAPTER VII

INFANT MORTALITY

The awakening of the world to a consciousness of the immense sacrifice of infant life is recent; most of this awakening has come during the past twenty years. Statistical studies upon an extensive scale have shown how colossal and almost universal has been the "slaughter of the innocents." Thus infant deaths (under one year) at the present time amount to from twenty to twenty-five per cent of the total deaths in all civilized countries. On an average it may be said that of every one thousand infants born, two hundred of them die during the first year of life; that is, one fifth of all our babies never reach the stage where they can walk or talk.

Infant deaths are largely preventable. Adult deaths are inevitable. Herein is the helpful sign of this problem.

During the last ten years over two million babies less than a year old have died in the United States. That is a number equal to a dozen flourishing cities. Because these two million prospective citizens were babies, only their parents and recently a few sanitarians paid much attention to the loss. The baby is the citizen of the future, and it is certain that the lives of very many babies can readily be saved in the United States each year. Estimates, varying with the optimism of the statistician, state that from fifty to seventy-five per cent of these deaths are preventable.

The economic importance of the subject has been forced upon the attention of certain European countries, particularly Germany and France. The steadily declining birth rate in almost all the higher civilized countries makes the saving of infant life of national importance. The decline

in the birth rate in eleven European countries has been from an average of 33.7 to 30 per thousand, or about ten per cent of the births. No similar decline has yet appeared in this country, owing to the influx of immigrants into our large cities. The birth rate in the rural regions and among the better classes, however, is showing a decided decline. The effect of immigration is best illustrated by the fact that in New York City in the best residential portion the present birth rate is four per thousand, while in the tenement district it is forty to forty-five per thousand.

Infant mortality is not expressed as other death rates are expressed; that is, the ratio to the whole population. Infant mortality is recorded as the number of deaths of children under one year of age to each one thousand births recorded during the year. It is assumed that the migration of children to and from a district counterbalance each other. For the reason that the registration of births in this country is very lax the infant mortality rates are not nearly so accurate as the figures obtained from foreign countries.

The infant mortality is higher in cities than in the country. Extremes are found in mill towns, such as Fall River, which has an infant mortality of 239.7 to 304.7. This is hardly exceeded by Preston, which for a long time claimed a very black record among the industrial cities. In Charleston, South Carolina, the infant mortality rate is 419.5, and in the District of Columbia, 274.5. In other Southern cities, such as Savannah, Mobile, Key West, Atlanta, Lynchburg, Richmond, etc., the figures are also above 300. These stupendously excessive figures are accounted for in part by the exceedingly high death rate among the negroes, and the incomplete registration of births. The figures from our Southland are balanced by such as Biddeford, Maine, 311.6; Fall River, Massachusetts, 304.7, and other mill towns in the North. The best evidence at hand indicates that there has been very little decline in infant mortality. Holt studied the question and found that there has probably

been some improvement in the death rate of children under five years of age during the past fifty years, although a study of the vital statistics in New York City shows that the infant mortality is about the same now as it was a hundred years ago.

The baby, like the fledgling, is "all mouth and stomach." The rate of growth is enormous; that is, a baby weighing about seven pounds at birth will, under normal conditions, weigh about twenty-one pounds at the end of the first year. In other words, the baby has trebled its weight in a year. The strain upon the digestive apparatus to furnish nourishment for this great growth and development frequently results in a breakdown and ends in disaster.

The causes of infant mortality

There is no doubt that many an infant is sent to an early grave through drinking dirty or infected milk. However, the quality of the milk is by no means the whole story. The causes of infant mortality are multiple and complex. In order to determine just how much of the great volume of sickness and the high percentage of deaths among infants during the first year of life is due to milk,we must examine into the principal causes of infant mortality.

The first and chief cause of infant mortality is infancy itself. This is the period in which the organism has the feeblest resistance. In this respect it corresponds to old age. The two extremes of life have been compared to the candle which flickers feeblest when lit and again when burning out.

In general, the fundamental causes of infant mortality are poverty, ignorance, and neglect. As the direct result of poverty we have poor housing in overcrowded districts, vitiated air, the necessity for mothers to work late in their pregnancy and very soon after confinement, insufficient food for nursing mothers, improper food for children, deprivation of mother's milk, inability to escape from the con-

sequences of bad surroundings such as excessive heat of summer and cold in winter, insufficient rest and recreation, etc. Ignorance of the simple facts of hygiene and infant feeding is an immense factor, which is quite as disastrous, if not more so in its consequences, than is the use of bad milk or improper food. Neglect may be due to intemperance or vice in the parent, but often is the result of poverty.

The chief causes of death during the first year of life among 44,226 deaths under one year of age in the cities of New York, Chicago, Boston, and Philadelphia are as follows: —

Acute gastro-intestinal diseases	28 per cent
Premature congenital debility and marasmus	25
Acute respiratory diseases	18.5
Acute infectious diseases	5.4
Tuberculosis (all forms)	2
Syphilis	1.2
Malformations, injuries at birth, and other conditions of the newborn	5.8
Convulsions	3.4
All other causes	10.2

From this total it will be seen that the diarrhœal diseases are so important that they practically control the curve of infant mortality. These are all grouped under the familiar term "summer complaints." One of the most striking facts about the curve of infant mortality is its seasonal prevalence. The great bulk of the slaughter occurs during the heated term of the summer. The reasons for this are the depressing effect of the heat itself, the activity of the bacteria, and a complication of other factors which influence the delicate mucous membranes of the baby's stomach and intestines.

One of the overshadowing factors in infant mortality is artificial feeding. In New York the health department estimates that eighty-five per cent of all infant deaths are

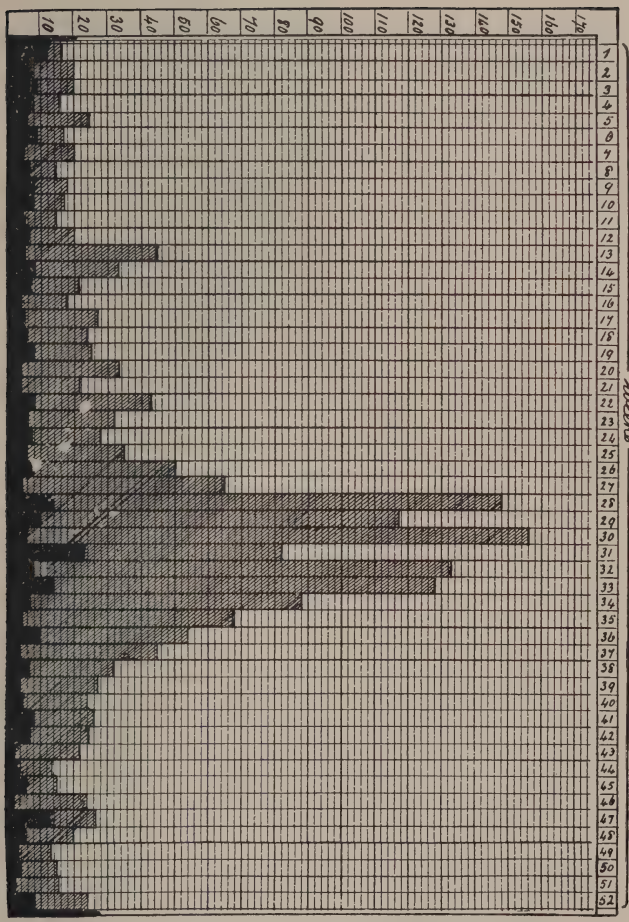


FIG. 65.—Chart showing the relative mortality from gastro-intestinal disease in breast-fed and bottle-fed infants, 0–1 year of age, in Paris, by weeks and throughout the year.

Breast-fed infants=■.
Bottle-fed infants=▨.

in those artificially fed. Tyson states that of 150,000 deaths in Great Britain, seventy-five per cent were in those raised on the bottle. Kober collected 54,047 infant deaths at home and abroad, eighty-six per cent of which were artificially fed. In Munich the mortality of bottle-fed infants is eighty-five per cent and that of breast-fed fifteen per cent. The State Board of Health of Massachusetts has confirmed the figures that ten babies who are artificially fed die to every one which has received its natural food from its mother. Further, that twenty-eight per cent of these deaths are from acute gastro-intestinal diseases most prevalent in the summer-time.

An infant raised on cow's milk then has from four to ten chances to die to one of those fed on mother's milk. This is partly due to the composition of the cow's milk, but mostly to the bacteria and the bacterial products. It is not the cow, nor the board of health, nor the milk inspector, nor the dairyman who is most concerned, or who has the greatest power in preventing the great infant mortality; but the mother.

One of the most striking evidences of the dangers of artificial feeding and the advantages of breast feeding are shown in Budin's chart, which gives the relative mortality from gastro-intestinal diseases in breast-fed and bottle-fed infants, under one year of age in Paris, by weeks throughout the year. This chart shows both the seasonal prevalence of the summer complaints, and the great disproportion between the mortality in the breast-fed and the bottle-fed babies.

Breast feeding requires very little experience, and may be done successfully by those who are of a very low grade of intelligence and among the poor. In other words, breast milk is the cheapest, cleanest, freshest, and best food for babies. On the other hand, artificial feeding is not successful unless carried out with intelligence and experience and, at the same time, with a certain amount of money to secure

reliable milk and skilled assistants to carry out the teachings of modern science.

Infant mortality is a class mortality. Any one who gives the subject attention is at once struck by the marked contrast between the death rate of the children of the poor and those of the rich. The reasons for this must now be evident.

Clay estimates that in England, among the aristocratic families, the infant mortality is ten per cent; in the middle class, twenty-one per cent; and in the laboring class, thirty-two per cent. This difference among the various classes is most striking in the case of the acute intestinal diseases.

Holle states that of the one hundred and seventy deaths during the first year of life, investigated in Graz in 1904, which were caused by gastro-intestinal diseases, one hundred and sixty-one were among the poor, nine among the well-to-do, and none among the rich. The conclusion is inevitable that intelligence, care, and money may purchase not only health but life.

England, Germany, and Switzerland have had, for many years, laws forbidding the employment of women in factories for a certain number of weeks after confinement. In some countries, such as Spain and Italy, the employment of women in industry is forbidden for one month before confinement. Such prohibitory laws are not effective unless they are supplemented by some adequate provision, public or private, for the welfare of mothers whose necessities compel them to work under such conditions. Such measures have actually been put into force officially in Germany and Austria. It must also be remembered that it is not only in factories that women are compelled to work hard and for long hours: the exacting duties of the household, particularly of the poor, require the mother's attention up to the very moment of confinement and frequently a few days thereafter.

In Boston a number of philanthropic agencies are accomplishing much good work along these lines. For exam-

ple, there is the Committee on Infant Social Service of the Massachusetts Municipal League which concerns itself principally with prenatal influences. Then there are a number of milk stations, more or less liberally supported, to furnish the baby clean milk, modified if necessary to suit its needs. The Milk and Baby Hygiene Association, in addition to furnishing milk, has physicians and nurses to teach mothers how to care for and feed themselves and their babies. The Instructive District Nursing Association and other philanthropic societies lend a helping hand.

Infant mortality and milk

From what has already been stated, it must be perfectly evident that the milk is only one part of the story. The great infant mortality is caused by a complication and combination of many influences. Bad milk is only one of the many factors which cause an excessive infant mortality. In other words, if all the milk in the world were fresh, pure, and clean, the infant mortality would still be excessive, and diarrhœal diseases would still carry off schools of babies in the summer-time. Just how much the infant mortality could be reduced by furnishing good milk and not changing any of the other factors cannot be stated, but it is my opinion that the reduction, while evident, would be disappointingly small.

Freeman believes that the decline in the infant mortality in the United States during the first ten years, especially in New York City, is due, for the most part, to the decline in mortality from summer diarrhœa, and states "that the general adoption of pasteurized and sterilized milk for infant feeding is by far the most important agency." Holt states that "the heating of the milk fed to infants in summer by one or the other method is now very general among the tenement population of New York and has been a factor of no inconsiderable importance in the reduction of infant mortality in the hot months."

Many of the diarrhœal diseases of babies are infectious in nature; that is, they are communicated from person to person just as typhoid fever, cholera, and other intestinal infections are transmitted. Many of the acute cases of summer complaint are really dysentery, and acute infectious diseases caused by the *Bacillus dysenteriæ*. This form of dysentery occurs in epidemics, and also is endemic in our climate and may be entirely independent of the milk supply. In Japan, for example, where milk is not commonly used as an article of diet, devastating epidemics of bacillary dysentery have occurred.

It is out of the question to anticipate such good results from artificial feeding as from breast feeding. All are agreed that if the child must be artificially fed, fresh, clean, and pure milk should be used. If infants must depend upon the stale, dirty, and uncared-for milk that forms the bulk of the supply in large cities, it would be much better, especially in the summer months, to practice pasteurization.

Infants' milk depots in the United States

A committee consisting of Dr. Kerr, Dr. Coit, and Dr. Freeman, representing the American Association of Medical Milk Commissions, collected the following data concerning infants' milk depots in the United States in the year 1910. The following chart shows the name of the institution, its object, how it is operated, and how maintained: —

Institution	Object	How operated	How maintained
Albany, N. Y.: Central Christian Mothers' Union.	To conduct an infants' milk depot.	By depot and visits....	By the union.
Baltimore, Md.:			
The Babies' Milk Fund Association.	To furnish to mothers who need it best milk for their babies.	.....do.....	
Council milk and ice fund.	To distribute milk and ice to needy persons, and to sell pure milk at nominal prices to reduce mortality.	Visits made after certificate from physician; tickets issued for milk and ice, which are delivered at homes.	Appropriation made by Federated Jewish Charities of Baltimore.
Boston, Mass.:			
Women's Municipal League, committee on infant social service.	Improvement of health of babies.	Visits by nurses; clinics.	
Milk and Baby Hygiene Association.	To improve milk supply, to prevent sickness and reduce mortality among infants, and to increase health and vitality of children and mothers.	By milk depots, visits, and conferences.	By private charity.
Buffalo, N. Y.: Babies' Milk Dispensary of Buffalo.	To reduce infant mortality; to help and teach mothers; to improve general milk supply.	By laboratory, distributing stations, consultations, and visits.	By private subscriptions and sale of milk.
Chicago, Ill.: Infant Welfare Society (formerly Milk Commission of Chicago).	To supply infants with pure milk at cost or below from distributing stations.	Central pasteurizing and distributing station, and substations.	
Cleveland, Ohio: The Babies' Dispensary and Hospital.	To reduce infant mortality by preventive measures.	Central and branch dispensaries, milk laboratory and stations, consultations and visits, outdoor ward during summer, control of milk farms, supplying milk to nurseries.	
Dayton, Ohio: Milk Commission Montgomery County Medical Society, free milk fund.	Distribution of milk to worthy poor.	Through physicians, charity nurses, and organizations.	By contributions and money raised by ball game.
Detroit, Mich.: Detroit Milk Fund.	To educate mothers in the care of infants, and to supply milk to the poor.	By clinics and visits...	By private charity.
Hartford, Conn.: Babies' Hospital (Inc.).	Treatment of babies under 2 years suffering with gastro-intestinal diseases.	By a committee.....	By voluntary contributions.
Honolulu, Hawaii: Palama Settlement.	To reduce mortality among infants, and to raise the standard of milk sold in the city.	Distribution of milk, instruction of mothers in care of infants.	By donation and sale of milk below cost.
Indianapolis, Ind.: Pure Milk Commission of the Children's Aid Association.	Prevention of infant mortality.	Distribution of milk, instruction of mothers.	Private contributions and appropriations.
Kansas City, Mo.: Kansas City Pure Milk Commission.	To provide proper milk for infants who otherwise would be unable to obtain it.	Central laboratory and distributing stations.	Subscriptions, donations, and receipts from sale of milk.
Lawrence, Mass.: Lawrence Sanitary Milk Commission.	To supply clean milk and give instruction in baby hygiene.	By classes of instruction and visits.	By subscriptions.
Louisville, Ky.: Babies' Milk Fund Association.	Distribution of clean milk, scientific feeding of young children, care of sick children, education of poor mothers.	By laboratory, stations, lectures, and visits.	

Institution	Object	How operated	How maintained
Lowell, Mass.: The Lowell Guild.	To supply infants with pure, fresh milk, teach mothers to feed and care for their children.	By milk station and visits.	By public subscription.
Milwaukee, Wis.: Visiting Nurse Association, two summer day camps.	See answer to next question.	Cares for sick poor in homes, for children with intestinal disorders in camps.	
Newark, N. J.: The Babies' Hospital Milk Dispensary.	To prevent infant mortality, educate mothers, and teach infant hygiene.	By hospital, dispensary, and nurses.	By voluntary contributions.
New Bedford, Mass.: The Charity Organization Society.	To furnish pure milk for infants and invalids of the tenement house district during the summer.	Stations maintained, visiting nurse employed.	By private contributions.
New Haven, Conn.: Consumers' League, milk depot.	To furnish pure milk for infants and children up to 2 years.	By distributing station.	
New York City:			
Division of Child Hygiene, Department of Health.	To give instruction in baby hygiene and home sanitation.	Lectures, clinics, district offices, care of sick poor.	By appropriation from the city.
New York Diet Kitchen Association.	To prevent infant mortality, give special attention to cases of tuberculosis, and furnish pure milk to other cases needing it.	By stations, or "kitchens," and visits.	By subscriptions, donations, and a small endowment.
Good Samaritan Dispensary.	To furnish pure milk for infants and invalids.	By dispensary and diet kitchen.	For adults, by fund raised by dispensary; for children, by fund raised by Mrs. Felix Adler and Mrs. Isaac Adler.
Nathan Straus Laboratory.	To reduce infant mortality by feeding infants proper milk.	By milk depots.....	By Mr. Nathan Straus.
New York Milk Committee.	Improvement of milk supply, reduction of infant mortality, and education of public to the proper use of milk.	By infants' milk depots (with other means).	By a private society maintained by voluntary contributions.
Wilkes' Dispensary, out-patient department of St. Mary's Free Hospital for Children.	The medical and surgical treatment of infants and children.	By dispensary	
Peoria, Ill.: Associated Charities.	To preserve life, by giving free medical attendance and nursing, and providing pure milk.	By dispensary and visits.	
Pittsburg, Pa.: Department of health of the city of Pittsburg.	Distribution of good milk to babies otherwise unable to obtain it; instruction of mothers in feeding and care of babies.	By dispensaries and visits.	By the city of Pittsburg.
Providence, R. I.: Providence District Nursing Association.	Protection of infant life by education of mothers or those who have care of children.	Through visits at home, clinics, school for mothers, and day camps.	By voluntary contributions, donation days, and aid of Providence Medical Association.
Rochester, N. Y.: Rochester Milk Depots.	Information of mothers and protection of child life.	Central milk station on a farm; 5 stations in school buildings, each station in charge of a nurse with a visiting nurse on duty.	
St. Louis, Mo: St. Louis Pure Milk Commission.	Supervision of production of certified milk; furnishing pure milk for infant feeding among the poor; clinical and home supervision of feeding cases.	A laboratory, distributing stations, clinics, physicians, visiting nurses.	By private donations, assisted by St. Louis Provident Association.

Institution	Object	How operated	How maintained
St. Louis, Mo.—Contd. United Hebrew Charities.	Distribution of pure milk.	Milk station in connection with St. Louis Pure Milk Commission.	Modified milk supplied by the milk commission.
Clinic for infant feeding of St. Louis Children's Hospital.	Proper feeding of infants.	Through feeding clinics, with assistance of social-service committee of the board of trustees.	By efforts of board of trustees and directors of hospital.
Kingdom House Feeding Clinic, Kingdom House Settlement.	To supply pure and clean milk to babies in congested districts.	By feeding clinic.....	By private charity.
Springfield, Ohio: Baby's Milk Dispensary.	Supply of inspected milk to poor babies.	By out-door camp for infants, education of mothers.	By public subscription.
Washington, D. C.: Nathan Straus Pasteurized Milk Laboratory.	To lessen infant mortality.	Distribution of modified, pasteurized milk in nursing bottles.	By Mr. Nathan Straus.
Washington Diet Kitchen, with baby milk stations situated at Neighborhood House and Noel House.	To distribute food to the indigent.	Through the visiting nurse society; by kitchen and stations.	By subscriptions and donations.
Instructive Visiting Nurse Society of the District of Columbia, department for prevention of infant mortality.	To coöperate with the health department of the District of Columbia in the prevention of infant mortality.	.....	By private charity.
Waterbury, Conn.: Waterbury Visiting Nurse Association.	To provide nurses for the sick poor, to furnish milk for sick babies.	By milk station, day camp, depots, instruction to mothers.	
Wilkes-Barre, Pa.: Wyoming Valley Society for the Prevention and Treatment of Tuberculosis.	Improvement of the milk supply.	Distribution of milk prepared in laboratory supervised by society.	
Worcester, Mass.: Worcester Conference on Child Welfare.	To furnish pure milk to children.	By milk stations conducted during summer by the milk committee.	By public philanthropy.
Yonkers, N. Y.: St. John's Riverside Hospital.	Sale of pasteurized milk, education by literature and instruction.	Milk dispensary and visits.	By the hospital, by subscription and sales of milk.

CHAPTER VIII

FROM FARM TO CONSUMER

The farmer

One of the real sources of trouble in the milk industry is that the great bulk of the milk comes from the small farm, and is there regarded only as a by-product. The small farmer keeps a few cows for his personal use. The yield is more than he needs, and he sells the excess. The farmer gives the subject small attention and finds it unprofitable to comply with the exactions of modern sanitary requirements.

It is the opinion of many persons who have given the question thoughtful consideration, and whose judgment is worthy of respect, that the day of the small dairyman is doomed; that the production of milk will gradually and inevitably drift into the hands of larger dairies where economic conditions justify competent assistants, skilled supervision, and efficient equipment. In other words, the dairy industry is a special industry requiring technical skill of a high order and must become a specialty like other trades and professions.

The crowding-out of the small farmer is not to be lightly regarded, for he has human rights and society must grant him economic justice, but the crossing of the roads has been reached and the sign-posts are plain — either the farmer must comply with the exactions of the sanitarian or his milk will soon find no market. Fortunately it has been shown that, by the exercise of cleanliness and a little ice, any farmer can produce milk that will come within the present sanitary requirements of market milk, and with

almost no increase in expense. It is not necessary to have marble stables, onyx barns, and silver-plated stanchions: simply cleanliness and cold are enough. An intelligent appreciation of the problem and a knowledge of the sources of bacteria will eliminate ninety per cent of the farmer's troubles.

Coöperation is one of the ways by which the small farmers can help each other. Through coöperative dairies, mutual helpfulness, and modern methods of combination much may be accomplished to save the situation.

The attitude of the farmer must be taken into account. It is difficult for the farmer to understand why the milk he produces can be as harmful as is sometimes claimed. He uses the milk for his own family; his own baby, red and rosy, is raised on it. Still, he is told it makes the city baby ill. He naturally cannot understand it, and in many cases refuses to believe it. The farmer forgets that the milk he uses is not the same when it reaches the city. He also forgets that the city baby is not the same as the country baby. On the farm the milk is fresh twice a day, and the baby is nurtured by God's sunshine and fresh air and has all the advantages of country life. The country baby has greater powers of resistance than the baby bred in the tenements. Again, the farmer is apt to forget that between the time the milk leaves his place and when it reaches the consumer in the city many wonderful things have taken place. The milk has passed through a number of hands, is two days older, the bacteria have grown, undesirable chemical substances have developed. It has received additional dust, dirt, and perhaps infection on its trip. It is no wonder that the fresh milk of the country may agree with the farmer's baby while the same product, stale and bacteria-laden, may disagree with the city baby.

The attitude of the farmer is often unfortunate, but he cannot be blamed for getting out of patience with the subject. He is made the butt of the cartoonists and is ham-

mered at from all sides. He is inspected and re-inspected, preached to, lectured at, scolded, and the object of legal action. He is pestered with the enthusiast, the reformer, the sanitarian, the lawyer, the baby's mother, and the baby's doctor. He is showered with advice, some of it contradictory. In this predicament he does not know which way to turn. If the attitude of the farmer is often unfortunate, the attitude towards the farmer is frequently equally unfortunate. Too often he is regarded as a back number, unprogressive, incompetent, and even dishonest. As a class no finer stock is to be found in the world than the sons of the soil. The city replenishes its wornout and effete inhabitants with the brawn, brain, and character of the country boy and girl. The harsh, arbitrary methods sometimes directed against the farmer are not only unjustified, but delay and complicate the solution of the milk question. Much quicker progress will be made through mutual respect, a helpful attitude, and a certain amount of patience necessary for all large sanitary reforms.

Confidence in the producer is an important link in the chain. As soon as the public has this confidence and is satisfied that the milk is produced by clean methods and handled in sanitary surroundings, there will be more milk consumed than there is to-day and at a better price. The farmer cannot be expected to rebuild his barn, pay higher wages for better help, buy more ice, and put in improved equipment without some recompense. This should come in a higher price for a higher quality of milk.

It is only fair to the farmer, in case his milk is refused and denied a market on account of contagious disease upon the farm, that he should be compensated for the loss. The farmer cannot be blamed when a case of typhoid fever occurs in his family or among any one of the farm hands. More often the infection is contracted as a result of negligence of the community to afford proper sanitary protection. Many of the large dairymen not only compensate farmers for milk

that is not used on account of contagious diseases, but in some instances even pay the farmer a premium for early information concerning the presence of communicable diseases on the farm.

The farmers feel that the large contractors are against them. They state that they keep him down, pay him a poor price, and mistreat his milk. If the price of hay goes up, the contractors raise the price of milk in the city at once, but pay the farmers no more. Whether this is so or not, the farmers feel that they are down-trodden and do not receive a square deal.

The farmer obtains a "natural" product over which he has little or limited control. He cannot know the amount of butter-fat, the total solids, or the number and kind of bacteria in the milk of each cow each day. Yet he is liable to prosecution and punishment if the composition of the milk does not comply with the law. In large dairies it is possible to employ a bacteriologist and chemist to make daily examinations of the mixed milk and frequent examinations of the milk of each individual cow. This is evidently impracticable in the small dairy. If the farmers themselves were as determined to produce a good quality rather than a great quantity of milk, much good would be done. They would soon learn that it is possible to produce a large quantity of a good quality and at a better price.

The price of milk

One great handicap in the development of the milk industry is the fact that the dairy business has been largely built up on a cheap basis with cheap cows, cheap food, cheap stables, cheap labor, and cheap prices for the product. Farm labor is the cheapest labor of all labor. This is one of the reasons why so much of the milk is poor milk. The question of getting efficient and intelligent labor at any price which the farmer can ever hope to pay is an important aspect of the problem.

Farmers will, however, produce good milk if given suitable financial reward for its quality. One great stumbling-block is the disinclination of the consumer to pay a fair price for a fair article. There is much opposition on the part of the consumer to pay a higher price for milk. There is a curious psychology in this: While begrudging one cent more a quart for milk, he supinely submits to an increase in the cost of almost everything else. There is little complaint about the price of beer, whiskey, or cigars. Many a person will pay five dollars for a quart of champagne without a murmur and then throw up his hands in despair at certified milk costing sixteen cents a quart, or clean milk at ten cents a quart. Dirty milk is dear at any price. Infected milk is an extravagance that even the millionaire cannot afford; safe milk at a fair price is one of the cheapest forms of insurance.

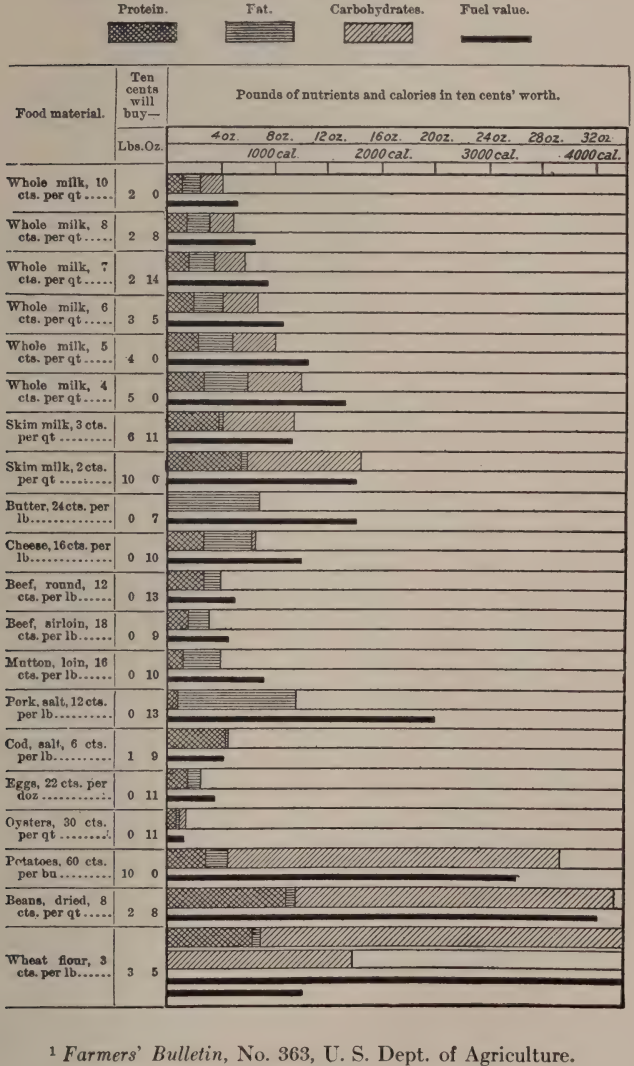
The farmer is not a philanthropist, but a business man. His enterprise must be an economic success or it will prove a sanitary failure. Farmers are just as liberal and just as fond of giving away money for charitable purposes as any other class in the community, but before they can give money they must first earn it. In other words, the farmer should receive a fair price for the milk he produces.

When we face the problem in its practical aspects we shall find that the economic factors are paramount. The price of milk rules even its sanitary quality with a hand of iron. No matter how much the idealist may chafe under the sway of the almighty dollar, he will soon find that practical progress is very difficult without taking the money side into consideration. In all fairness the farmer is entitled to a higher price for his milk to compensate him for the extra expense necessary to produce a milk of higher grade. Fortunately a sanitary milk may be produced by any farmer with comparatively little increase in expense.

The farmer must be reasonable, for it has been shown that modern sanitary requirements are not as burdensome

PECUNIARY ECONOMY OF MILK AND OTHER FOODS[1]

Amounts of actual nutrients obtained in different food materials for ten cents.


Protein.
Fat.
Carbohydrates.
Fuel value.
Food material.
Ten cents will buy—
Lbs. Oz.
Pounds of nutrients and calories in ten cents' worth.
4 oz.
8 oz.
12 oz.
16 oz.
20 oz.
24 oz.
28 oz.
32 oz.
1000 cal.
2000 cal.
3000 cal.
4000 cal.
Whole milk, 10 cts. per qt 2 0
Whole milk, 8 cts. per qt 2 8
Whole milk, 7 cts. per qt 2 14
Whole milk, 6 cts. per qt 3 5
Whole milk, 5 cts. per qt 4 0
Whole milk, 4 cts. per qt 5 0
Skim milk, 3 cts. per qt 6 11
Skim milk, 2 cts. per qt 10 0
Butter, 24 cts. per lb 0 7
Cheese, 16 cts. per lb 0 10
Beef, round, 12 cts. per lb 0 13
Beef, sirloin, 18 cts. per lb 0 9
Mutton, loin, 16 cts. per lb 0 10
Pork, salt, 12 cts. per lb 0 13
Cod, salt, 6 cts. per lb 1 9
Eggs, 22 cts. per doz 0 11
Oysters, 30 cts. per qt 0 11
Potatoes, 60 cts. per bu 10 0
Beans, dried, 8 cts. per qt 2 8
Wheat flour, 3 cts. per lb 3 5

[1] *Farmers' Bulletin*, No. 363, U. S. Dept. of Agriculture.

as has been represented in some quarters. The extra cost of producing a clean milk of sanitary grade is not excessive.

According to the census of 1900 the average price paid the farmer for milk in this country was 8.7 cents a gallon; that is, about 2.2 cents a quart. What can we expect at such a price? At present, farmers are paid somewhat more (the latest figures not being available), but still too low. These figures justify the general belief that the farmer gets too little for his milk. On the other hand, it is said the consumer pays too much and the middleman gets all the profit. Whether this is so or not is difficult to make out. One thing, however, is sure; that is, that the farmer does not receive enough and there is considerable economic loss in transportation, handling, and distribution through lack of coöperation.

At the price ordinarily paid for milk in our large cities, it is a food of reasonable cheapness, and at the prices prevailing in small cities and country towns, milk is a very economical food. Under any circumstances protein is obtained at a much cheaper price in milk than in meat or eggs. On the other hand, it is a more expensive food than cereals, potatoes, and certain vegetables, flour, bread, crackers and also beans and peas if considering only their caloric value.

The comparative value of milk and other foods is shown in the accompanying table, and has already been referred to under the paragraph upon "Milk as a Food." In comparing the price of milk with that of other foods, it is important to remember that it requires no preparation for the table, which adds to the cost of foods, such as cereals and vegetables, which seem cheap in their raw state.

The variation in the composition of milk is so great that it is entirely possible that one man may pay nearly twice as much as his neighbor for the same amount of nutriments when both buy it at the same price per quart.

Hospitals, orphan asylums, babies' nurseries, and other institutions and homes where children and invalids are

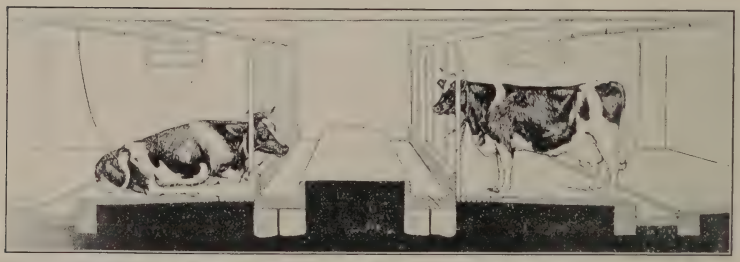
cared for, often, for economic reasons, purchase the cheapest milk to be found on the market. As a rule proposals are asked and bids invited and a contract issued to the lowest bidder, irrespective of quality and other considerations. In the course of my investigations I have found this to be a very prevalent and serious custom. The consequence is that such institutions which should have the very best of milk often have the worst. The trustees of such institutions should not be satisfied unless their wards receive clean, safe, and satisfactory milk.

Up to 1890 milk was sold regardless of composition. In that year Babcock discovered a practical test for determining the amount of fat contained in milk. Since then milk is sold to creameries, at cheese factories, and to large contractors on the basis of its butter-fat content. Only the small consumers buy milk on the basis of bulk. As soon as economic conditions require it, milk will be sold at a price depending upon its nutritive value, just as coal is bought and sold by its caloric value, and not alone by weight.

As a matter of fact, the price of milk is based upon broad basic principles beyond the power of any one individual to control. This is largely due to the fact that milk is mainly a by-product of the small farmer. He keeps a cow for family use and has an excess. The excess goes largely into butter and cheese. Butter and cheese are concentrated foods, keep better than milk, and may be transported farther; hence the price of butter and cheese is a very great factor in controlling the price of milk. Other factors which loom large in the cost of production are the value of the crops, the cost of labor, the price of land, the cost of beef, and whether cows may be fed on crops not otherwise useful or profitable.

The price of milk has much more than a simple academic interest, for it influences our entire social fabric. If the price is too high, especially for the poor, less of it is used, children are underfed, or bad milk is purchased. In any event, we should remember that the price of milk is the key

MANY AN UNPROFITABE COW IS KEPT BECAUSE A CAREFUL RECORD IS NOT TAKEN OF THE YIELD FURNISHED AND THE FEED CONSUMED



PROPER CONSTRUCTION OF A BARN FLOOR, SHOWING HEAD TO HEAD ARRANGEMENT. NOTE THE DEEP TROUGH BEHIND THE COWS

to the situation. With milk, as with almost everything else, we get what we pay for; no more; sometimes less. It is cheap to buy good milk; it is expensive to buy bacteria and dirt.

Milking the cow — resemblance to a surgical operation

The day has long gone by when any member of the household or one of the farmhands runs over to the barn in the morning and again in the evening to milk the cows, without any special preparation or precautions — in a dirty barn where the cows are kept with horses, with a lean-to for the chicken roost and a manure pile outside the door, and the pig-pen near by. Perhaps the water comes from a shallow well a few feet from the privy, with every chance of becoming contaminated; there are no facilities for heating water to cleanse the milk pails and cans, no milk room, insufficient means for cooling milk, and a general lack of facilities. These old-fashioned methods may satisfy the personal needs of the small farm where milk is only a by-product and the yield is all used upon the premises, but just as soon as the milk is shipped to village, town, or city, another responsibility enters that cannot be ignored. The domestic arrangements must be kept separate from the milk industry. Therein lies one of the chief dangers of infecting the supply. The milker must be cleanly in his habits, and should be intelligent enough to understand what it is all about. Above all, the milker should be conscientious enough to wash his hands, and use the same care at four o'clock of a winter's morning, when no one is looking, as he does on a bright summer's afternoon in the presence of a gallery.

It is the general practice to have a man milk for only a few hours each day, as it is commonly believed that it is not possible for any man, however strong, to continue the muscular effort required for a longer period of time. It is also the common practice to require the milker to perform

the miscellaneous work about the farm during the intervals. He therefore frequently comes to his task, which is a delicate operation, all tired out and covered with dirt. It is unreasonable to expect the highest grade of efficiency under such conditions. Milking the cow is a very special operation requiring aptitude, training, and skill corresponding to other special trades. Proficiency is gained through experience. It is advisable, when practicable, to have the milkers specialize in this one particular part of the industry and to devote their entire time and attention to doing it in a thorough manner. It will be found at first that a milker will not be able to milk more than a few hours a day, but by practice he will soon be able to milk eight or ten hours without any special difficulty. Operators may be found in many factories who work eight or ten hours a day at work requiring more concentration and greater muscular effort than that required in milking.

The milking should be done in a quiet, clean, and thorough manner and at regular times — as nearly as possible at twelve-hour intervals. The cow should not only be kept clean and fed regularly, but always treated kindly. Before the milking commences, the stable should be cleaned, but no work which would stir up dust or odors should be done within thirty minutes before milking-time. Next, the cows themselves should be cleaned and groomed. This work should be finished half an hour before milking, and the cows required to stand until they are milked. While the cows are being cleaned the stable should be ventilated. In cleaning the cows special attention should be given to the belly, udder, tail, groins, flanks, and legs. The method and thoroughness with which the cows are cleaned varies considerably in different dairies. They may be washed or scrubbed with water or soap and water, brushed and combed or even treated with a vacuum cleaner, which is in use in at least one certified dairy in this country. The cows should not only look clean, but be clean

in the sense that dust and dirt particles will not fall into the milk. The long hair on the udder and surrounding parts should be clipped, but not the bush on the tail. The tail must not touch the floor during milking. In some dairies the tail is tied up during milking. Just before milking the udder and surrounding parts should be thoroughly washed with clean, warm water and clean cloths and then wiped with a clean cloth, tightly wrung out and used only for the udder. Antiseptics may be used, but they must be thoroughly removed with clean water so that they will not get into the milk.

The process of milking has come to resemble a surgical operation so far as antiseptic methods are concerned. As in antiseptic surgery, success can only be achieved through cleanliness and scrupulous attention to minute details and an intelligent understanding of the problem. So it is with milking.

Clean milk can only be obtained by the same methods the surgeon uses to perform a clean operation. The principles and the technic are precisely alike. I could imagine no better training for a milkman than an apprenticeship of a few months in a surgical clinic where aseptic methods may be learned. It is no exaggeration to compare the operation of milking the cow to a surgical operation.

Those who milk cows should be taught to keep their fingers away from their mouth and nose at all times, especially after the hands have been washed and prepared. Just before milking, the hands should be thoroughly cleaned, using soap, a brush and warm water. They must then be thoroughly dried upon a clean towel. In some dairies antiseptics are used in cleaning the hands. After the hands are cleaned and dried, the milkman must be taught to remember that he should touch only three objects: (1) the top of the milk stool, (2) the milking-pail, and (3) the cow's teats. It is difficult for many men to remember this, but by persistence it soon becomes a matter of habit. This is one of the ad-

vantages of having special milkers who soon become accustomed to all the details of the work. If the milker has to sneeze, cough, or clear his throat, he should do so in an approved sanitary manner and take care that none of the spray which is ejected in coughing, sneezing, etc., gets into the milk.

Both the hands of the milker and the teats of the cow must be kept dry when milking. In good dairy practice wet milking is absolutely forbidden. In obtaining certified milk the hands must be rinsed, washed, and dried after each cow is milked. This may not be necessary in ordinary practice, but is advisable.

The milkers should wear clean white suits and caps. The suits should be laundered frequently, but better and cheaper than the laundry is to steam them once a day. When not in use the suits should be kept in a clean, ventilated place, and under no circumstances should be hung in the dwelling. They must be protected from dust, vermin, and infection.

The first three or four streams from each teat, known as the fore milk, should be drawn into a separate vessel and discarded. This is the portion of the milk richest in bacteria.

The milker should carefully watch the flow from each quarter of the udder and if it is bloody, stringy, or otherwise unnatural the entire yield from that cow should be rejected. If dirt gets into the milk or any accident occurs which might injure it, the entire contents of the pail should be discarded and the pail washed and sterilized before it is again used.

Milking-machines. Considerable ingenuity has been expended to devise a suction apparatus which will take the place of the hands. Some milking-machines do their work very well. To be successful, however, any innovation must increase efficiency or decrease cost; still better if it does both. When kept scrupulously clean and intelligently oper-

ated, milking-machines keep out extraneous bacteria and have the great advantage of preventing possible infection from the hands and person of the milker. Every device that avoids human touch is a distinct gain in the milk industry. The machines, however, are complicated and liable to accidents which are annoying, and are very difficult to keep clean. So far, no entirely satisfactory milking-machine has been devised.

The middleman

The middleman occupies a peculiar position in the milk industry. He is a necessity in all cities where the milk comes from distances farther than a wagon haul. The middleman buys the milk of the farmer, brings it to town, and distributes it to the consumer. In Boston and other large cities the middleman is known as the contractor.

The middleman is the point of attack from all sides. The farmer complains that the middleman pays him too little for his milk; the consumer complains that he charges him too much. The health officer attacks the middleman for violation of the milk ordinances, and the Government pounces upon him for combinations in restraint of trade. Altogether his lot is not a happy one. The competition is fierce and the methods not always above reproach. Nevertheless it is my belief that the middleman, or large contractor, is a power for great good in the milk industry. In fact, this concentration of the business is just the right key which fits the lock of many of the most perplexing problems in our subject.

It is evidently much easier to control, educate, and regulate a few large contractors than hundreds of small independent dealers. In Boston a large percentage of the milk is supplied through three large contracting firms. This concentration makes it easier for the health officer to enforce the ordinances, permits coöperation, which is so essential, and facilitates the administration of the law.

It is both an economic arrangement and a sanitary advantage.

The advantages of concentration are so very important that they deserve a special word. If the milk is handled for a large city by a few corporations it at once does away with the necessity of municipal milk depots. One of the first advantages is that a strict official surveillance may be kept over a few plants, while it is almost impossible to administer health ordinances in a satisfactory manner where thousands of small independent dealers are concerned. Thus in the case of Boston, three milk inspectors, one for each of the three large contracting firms, could accomplish infinitely more than thirty inspectors overlooking many small plants. The large contractors can afford to buy expensive bottle-washing machines, sterilizers, pasteurizers, mechanical filters, and, further, can better afford to replace antiquated machinery by improved methods than the small dealer. The supervision and control of pasteurization can be accomplished much more satisfactorily in large plants than in small. The washing and sterilizing of the bottles is, as a rule, more effective in a large establishment than in a small dairy. It is much easier to grade milk according to certain definite standards where it is all brought together. The large dairyman can afford to employ high-class and competent assistants, beyond the reach of the small producer. Further, consolidation is an economic advantage both to the middleman and to the health authorities. When it comes to distribution there is a distinct gain, for one wagon and driver can cover the ground of several wagons and drivers from independent sources.

One of the special advantages in the consolidation of the industry in large dairies is that the fluctuating demand for milk may readily be met. The large dairy may have an elastic supply for the reason that it may make profitable use of the excess. It is difficult for the small dealer to find an

economic use of his surplus. The large contractor finds it profitable to make by-products, such as butter, cheese, buttermilk, casein, milk sugar, etc. Also, he can dispose of skim milk and whey to better advantage than the small dealer. From the standpoint of human nature it is perhaps better to place all our eggs in one basket and then watch that basket. The sanitary conscience of a large contractor is in the public eye and he can ill afford not to comply with the requirements of progress. In Boston the large contractors have been forces for good in favoring constructive legislation, in fostering research, in educating both the public and the farmer, and in other useful ways.

When the large dairyman effects economy at the expense of efficiency he will usually find it to be an expensive process in the end, if not a dangerous one. The narrow margin of profit at which the milk business is carried on demands careful economy at every step. Thus drip machines have been devised so as to obtain the last drop of milk left in the cans after the contents have been poured out. This saving corresponds to the thumbing of egg-shells in order to save the egg-white that adheres to the shell. No serious objection can be had to these practices if carried out in a cleanly manner, but sometimes the saving of money results in the losing of quality. Thus I have in mind complicated regenerators in which the warm milk is utilized to heat the oncoming cold milk. The cold milk in turn cools the warm milk, thus saving so much steam and ice. These regenerators work entirely satisfactorily from a physical and economic standpoint, but are complicated, difficult to clean, and are apt to add bacteria to the milk.

Care of the milk in the household — the responsibility of the consumer

The farmer is inclined to hold the consumer responsible for the troubles which the consumer complains of. When milk sours, when sickness occurs as a result of using infected

milk, or when something goes wrong, the housewife blames the farmer or the dairyman. On the other hand, the farmer and dairyman say that the householder does not care for the milk properly.

The difficulty begins at the doorstep. The milk bottles are left by the driver on the sill. There they stand, mayhap, several hours. In the mean time the milk becomes warm, especially in summer; the street dust collects on the caps and lips of the bottle; stray dogs and cats lick the tops to which a little milk usually remains sticking; flies, ants, roaches, and perhaps other vermin are likewise attracted, and may leave infection or undesirable specks. Irresponsible boys and stray tramps may take a sly drink (the best of the cream layer) and perhaps fill up the void with water of doubtful origin. The possible mishaps to the milk bottle in the early hours of the morning are, indeed, numerous. By this time the milk in the bottle is perhaps warm, possibly it has incubated several hours in the sun. When the milk bottle is taken into the house a new series of possibilities arises. The bottle is carried gingerly by the servant's hands, which may be dirty with the early morning cleaning. I say the bottle is carried gingerly, for the reason that it is common practice to pick it up so that the fingers touch the lip of the bottle.

The bottle now passes into the cook's hands, which perhaps have not been washed since her early morning visit to the toilet. The bottle is now placed in an ice box, where it is supposed to be kept cold so as to check the growth of bacteria and delay deterioration. But the average household ice box is a snare and a delusion. They are either badly designed or poorly insulated; they are usually too small or insufficiently stocked with ice; frequently the doors do not fit tightly, which greatly interferes with their efficiency; and almost always they are located, for convenience, near the heat of the kitchen stove. Investigation of actual conditions shows that the household refrigerator

is more often a household incubator. Instead of being cold, it is only cool; sometimes actually warm. Milk, of course, cannot be kept well under such conditions. In the laboratory we are able to keep ordinary clean milk a week or two in a scientifically constructed refrigerator, while the same milk invariably sours within twenty-four to forty-eight hours in the domestic ice box. This, however, is not the end of the troubles, for now the bottle is removed from the refrigerator for use.

It is customary to open the bottle without wiping off the lip and little cup formed by the paper cap. This little cup is a catch-all for the dirt and dust of the wagon and street. It may hold dirty water from the melted ice which is heaped over the bottles in the wagon. Perhaps the paper cap is removed by pressure from the finger which slips into the milk and perhaps a soiled fork or other pointed implement is used to take out the stopper. In any case, the dirt and moisture on the cap are apt to fall into the milk. If the lip is not clean, the dirt upon it is washed off with the out-flowing stream. Meanwhile the paper cap has been laid upon the kitchen table, perhaps buttered-side downward, and is replaced, if the entire contents of the bottle are not used. Oftentimes the half-emptied bottle is permitted to lie around uncovered to collect flies, dust, and more dirt, as well as to absorb the odors of the kitchen. It is not unusual for milk bottles to be taken into the sick-room, or persons may drink directly from the bottle; sometimes milk bottles are used for holding turpentine, paint, carbolic acid, medicine, gasolene, and other things. Finally, it may not be carefully washed before it is returned. It is no wonder, then, that the farmer and dairyman have a counter-grievance against the consumer.

The watchword for the consumer is cleanliness and cold. If these two precautions are taken, the householder will meet her responsibilities in the case. If the entire contents of

the bottle are not used, the cap should not be returned, but a clean glass should be inverted over the neck of the bottle before it is returned to the ice box. A good ice box will have a separate compartment for milk and butter, or the milk bottle may be placed directly upon the ice. The milk bottles should always be cleaned and scalded out before they are returned to the dealer.

There is one phase of the responsibility, or, rather, irresponsibility, of the consumer that should be noticed. If the milk sours from neglect in the household, it is a self-imposed loss. If the milk becomes infected in the household, the infection, as a rule, remains in the household where it was caused. At least it does not, as a rule, cause large epidemics, as is the case when infection is introduced on the farm or at the dairy.

In the household, milk should be kept clean, cool, and covered.

The separation of the producer and consumer

The wide separation in distance between the producer and the consumer is one of the fundamental causes of the milk question. At first, milk was consumed on the farm that produced it; the village received its supply from the neighborhood; the growing towns drained the dairy farms of the immediate vicinity; even the larger cities for years and years obtained all their milk from farms within wagon haul. This was an enormous advantage, as it assured the freshness of the milk.

Fresh milk, next to clean milk, is the keynote of our problem. When cities and towns are supplied with fresh milk from near-by sources, the milk is handled by comparatively few hands, and the various sources of supply are kept separate. Hence widespread epidemics, due to the commingling of infection with a great bulk of milk as in the modern dairy, do not occur.

As the cities grew larger in size, a radical readjustment

took place so far as the milk problem is concerned. The suburban land became too valuable for dairying purposes, the farms were pushed farther and farther away from the centres of population. Improved means of transportation greatly facilitated this separation; but this separation increased the difficulties and complexities of the problem. The milk is no longer brought directly to the city. It passes through a number of hands. It is exposed to adverse conditions. The common carriers help to muddle the question. The middleman adds his difficulties and profits. The milk is mixed in large quantities, to add to the danger when infection is present. Finally, the milk is no longer fresh, and other difficulties arise, so that we are confronted with a perplexing and often serious situation.

When the producer and consumer were near neighbors and closely acquainted with each other, the one had a personal interest in the product he furnished the other. If the product, be it meat, milk, or what-not, caused sickness or death, there was a direct appeal to the producer; but the separation between the two has lulled the conscience of the producer. He no longer sees the results of his acts, and is skeptical concerning their dire consequences. Frequently the producer cannot be made to believe that he is responsible for the tragedies which sometimes result. The intervening distance, time, and circumstances help to strengthen the immunity of the producer in his own opinion. He is very apt to claim that the infection was introduced or the poison developed after the product left his hands. The fact that the personal contact between producer and consumer has largely been eliminated makes of the transaction in foodstuffs an impersonal business, like the trade in iron, cotton, or cement. It is human nature to concern ourselves more about the things we make for our friends and neighbors, whom we know, and see frequently, than it is for some far-off foreigner. This phase of the situation nourishes the tap-root of many of the difficulties found, not

only in the milk question, but in the entire food supply of the world.

The extent to which this separation of consumer and producer has taken place in the milk industry is patent when we recall that Boston gets most of its milk supply outside of a fifty-mile circle and some milk starts two hundred and forty-three miles from the city. New York City receives practically no milk within fifty miles and some of its supply comes from points as far away as four hundred miles. New York City uses about 1,600,000 quarts of milk a day, derived from 40,000 dairy farms.

Most of the milk supply of Chicago is produced within sixty miles of the city. A one-hundred-mile circle about the city would include nearly all the dairies producing its supply. In times of exceptional scarcity in the summer, sweet cream is shipped two hundred miles. The production of Chicago's milk within such a short distance of the city is in marked contrast with conditions in Boston and New York. Chicago uses about one million quarts of milk a day. The health commissioner estimates that, in 1910, 120,000 milch cows were necessary to furnish the city supply, making an average production of 6.3 quarts per day per cow.

The District of Columbia consumes about 76,000 quarts of milk a day, or about 0.4 of a pint per capita. This milk is produced on 1091 dairy farms from 17,688 cows. About one third is brought in by wagons and two thirds by steam and electric railroads. The cream is largely received from Philadelphia and New York.

Bringing the cow to the city

In order to overcome some of the difficulties that arise on account of the wide separation between the consumer and the producer, it has been proposed to bring some of the cows back to the city, to produce milk especially for infants and invalids.

We have frequently emphasized the fact that milk should be as fresh as possible, especially for infants, but evidently the city is no place for a milch cow. The keeping of live stock within the city limits is expressly forbidden by the health ordinances of almost all municipalities. This is a wise measure, for animals are a nuisance and may even be a menace to health. They favor the spread of flies, rats, and other vermin, and are a factor in the dissemination of parasites. It is practically impossible to keep a cow in a healthy condition for any length of time in a city, which is the worst imaginable place in the world for a diseased cow. While it is very important to bring the teat nearer the baby's mouth, we can hardly consider that the proposition of bringing back some of the cows into the city will meet with favor. A better and simpler method would be to improve transportation facilities so that the morning milk may be at our door within a few hours from the time it is obtained.

Classification of milk — the grades of milk

There are only two kinds of milk; good milk and bad milk. We would all welcome the day when this simple classification becomes effective. It is very easy to set up a theoretical ideal, but it is quite a different matter to establish this ideal upon a practical working basis. Thus it is with the milk question. It is very easy to say that all we want is fresh, clean, and safe milk, and that no other shall be allowed upon the market. If those who make these demands would start a dairy farm they would find the hill a very high and rugged one to climb. For practical purposes, therefore, milk is divided into a number of different grades.

The grades of milk refer either (a) to its sanitary quality, or (b) its nutritive quality; or a combination of both. From the nutritive standpoint, milk is graded largely upon its butter-fat content. From the sanitary standpoint, milk is graded as certified, inspected, or ordinary market milk.

The classification of milk now commonly accepted is: —

A. *Certified milk.* Also known as "guaranteed milk," or special milk of very high quality; sometimes spoken of as "babies' milk." Contains less than 10,000 bacteria per cubic centimetre.

B. *Inspected milk.* This is a clean, high-grade milk from tuberculin-tested cattle; also known as "household milk." Contains less than 100,000 bacteria per cubic centimetre.[1]

C. *Market milk.* All that does not comply with the requirements of class A and class B. This grade is sometimes called "pasteurized milk," because, by common consent, it should be heated before it is consumed. This milk in its raw state should not exceed 1,000,000 bacteria per cubic centimetre (New York), 500,000 bacteria per cubic centimetre (Boston), 100,000 bacteria per cubic centimetre (Rochester).

Many intermediate grades and sub-grades have been proposed. This, however, complicates the situation and serves no very useful purpose. The official classification recognized by the Government is, as above stated, certified milk, inspected milk, and market milk, and this classification is growing in popularity, for it is easy for people to understand, and meets the requirements of the dealer.

There is a growing tendency to grade milk into two great classes, namely, raw milk and pasteurized milk. Such a classification has much to commend it from the sanitary standpoint.

The classification adopted by the Commission on Milk Standards of the New York Milk Committee is as follows: —

[1] There is confusion as to just what inspected milk means. As a matter of fact, it means different things in different cities, even in the same city. Sometimes inspected milk is drawn from tuberculin-tested cows; sometimes not. It may be bottled on the farm or at the city dairy, and has other differences.

Class A. Certified milk or its equivalent.
B. Inspected milk.
C. Pasteurized milk.
D. Milk not suitable for drinking purposes.

The new milk regulations of the Department of Health of the City of New York, promulgated January 4, 1912, classified milk as follows: —

Grade A — For infants and children: —
1. Certified or guaranteed milk.
2. Inspected milk (raw).
3. Selected milk (pasteurized).

Grade B — For adults: —
1. Selected milk (raw).
2. Pasteurized milk.

Grade C — For cooking and manufacturing purposes only: —
1. Raw milk not conforming to the requirements for grades A and B.
2. Condensed skimmed milk.
3. Condensed or concentrated milk.

Milk standards

For a long time the only milk standards known were chemical standards. Special emphasis was laid upon the specific gravity of the milk, the amount of fat it contained, and also the total solids. Chemistry is a very old science, and chemists naturally applied their knowledge to milk long before bacteriology was born. Chemical standards, however, tell us more about the nutritive value of milk than about its sanitary quality. Thus a watered milk or a milk from which the cream has been removed is simply a fraud; if the milk is clean and the water that has been added is pure, there is no particular danger to health. Such practices may be compared to the dealer who gives us short weight or to one who sells us shoddy for all wool.

The bacteriological standards give us a much better idea of the sanitary quality of milk than the chemical standards. Bacteriology, however, has by no means supplanted chem-

istry. Chemical standards have been and remain very useful — indeed, necessary to detect adulteration, frauds, and to determine the grades of milk, etc.

Milk that meets standard requirements is not necessarily standard milk. The legal standards are minimum requirements and express inferiority if anything. The standards are the lowest grades that the law will permit. There are, in fact, three standards by which milk should be judged: (1) the chemical standards; (2) bacteriological standards; (3) standards determined by inspection. All three are necessary for the satisfactory control of the milk supply.

The principal chemical standards are those for butter-fat and total solids. The legal requirements for the butter-fat and total solids in milk vary somewhat in different states, as shown by the following table: —

LEGAL REQUIREMENTS — COMPOSITION OF MILK

Fat Per cent		Solids not fat[1] per cent	Total solids per cent
3.0	Idaho	8.0	11.0
	California, Illinois, New Jersey,* New York,* Wisconsin	8.5	11.5
	Montana, North Dakota, Ohio, Porto Rico	9.0	12.0
	Iowa,* Michigan,* Oklahoma*	9.5	12.5
3.2	Oregon, Utah	9.0	12.2
3.25	Association of Official Agricultural Chemists, Connecticut, Georgia, Indiana, Kentucky, Maine, Missouri, North Carolina, South Dakota, Tennessee, Texas, Virginia	8.5	11.75
	Washington	8.75	12.00
3.35	Massachusetts*	8.8	12.15
3.5	Hawaii*	8.0	11.5
	District of Columbia, Maryland*	9.0	12.5
	Louisiana, New Hampshire	9.5	13.0

* These states marked do not directly specify the solids not fat. The figure given in such cases is the difference between the required total solids and the required fat.

It has been found an advantage to keep the butter-fat standard relatively high and the total solids at a minimum of 12 per cent. This allows 8.5 per cent for solids not fat,

such as the proteins, milk sugar, and inorganic salts. A 3.25 per cent butter-fat and a 12 per cent total solids is the minimum that should be allowed.

If the law recognizes a low standard for total solids, it permits manipulation of the milk, such, for example, as adding water. It also encourages the production of milk from inferior cows. High standards encourage good dairy methods, require good feed, and place a premium upon the better breeding of milch cows.

The determination of fats and total solids is used to detect skimming or watering; however, it is possible to skim milk or water it, within limits, without the possibility of detecting it through the fats and total solids.

Milk is sometimes condemned and destroyed for having a low specific gravity. The specific gravity of the milk is easily and quickly obtained by means of a lactometer or Westphal balance. The specific gravity, however, is a very imperfect index to determine whether the milk has been skimmed or watered. Thus a low specific gravity may mean a rich milk with an unusual amount of cream. Usually, a low specific gravity means a watered milk. A high specific gravity may indicate either skimming or the addition of sugar or some other substance in solution. It is possible scientifically to mix skim milk with cream and sugar so that it will have a normal specific gravity but an abnormal composition.

If dependence is placed upon the total solids, mistakes may also occur. The total solids represent the proteins, fats, sugar, and inorganic salts. They may readily be tampered with. Thus sugar may be added to replace the cream that is taken off.

Milk is sometimes condemned and dumped upon the streets for the reason that it does not comply with the temperature requirements. Most milk regulations do not permit the milk to go above 50° F., and if found warmer than this the milk is condemned. Probably no one test is suffi-

cient to justify the destruction of milk on the streets. In other words, we cannot obtain sufficient information, "while you wait," to state with certainty that milk is dangerous from a sanitary standpoint. It is questionable whether the methods sometimes adopted by the health officer and exploited in the daily papers with great applause prove of sufficient permanent value to justify them. This refers particularly to pouring milk down the sewer because it is warm, or because it has a low specific gravity or does not comply in some other particular with the regulations. It is true that this is the only way by which farmers and dairymen may sometimes be reached, but it seems an unnecessary waste to destroy the milk, and it also seems that some other punitive or corrective measures would accomplish better results and be more lasting in their effects.

The following are the chemical standards which have been found best to suit scientific and practical demands: —

Cow's milk. Standard milk should contain not less than eight and one half (8.5) per cent of milk solids not fat and not less than three and one quarter (3.25) per cent of milk fat.

Skim milk. Standard skim milk should contain not less than eight and three quarters (8.75) per cent of milk solids.

Cream should contains not less than eighteen per cent of milk fat and be free from all constituents foreign to normal milk. The percentage of butter-fat in cream over that standard should be stated on the label.

Buttermilk is the product that remains when fat is removed from milk or cream, sweet or sour, in the process of churning. Standard buttermilk contains not less than 8.5 per cent of milk solids. When milk is skimmed, soured, or treated so as to resemble buttermilk, it should be known by some distinctive name.

The bacteriological standards for milk are based largely upon numerical counts. Certified milk must contain less

than 10,000 bacteria per cubic centimetre; inspected milk less than 100,000; market milk should not exceed half a million. This has been discussed under the question of bacteria in milk.

Milk is also graded upon the information obtained from inspection. This has also been discussed in another place.

Milk products

Government estimates show that about two thirds of all the milk produced for sale by the farms of the United States is used for making butter and cheese, while the remaining third is consumed directly as milk and cream. In addition to the products mentioned, milk and cream enter into the composition of a very large number of dishes that appear upon the table. Further, we have such products as ice cream, whey, clabber, junket; also buttermilk, kefir, koumiss, and other fermented milk products. Some of these deserve separate consideration, as they have a direct bearing upon health. Most fresh-milk products are capable of conveying the same infections that may be contained in the milk from which they are made; some of them, in fact, as cream or butter, are apt to contain these infections in concentrated form.

Cream. The composition of cream and its general properties have already been alluded to. The subject, however, deserves special consideration, for the reason that it has already become a special industry and contains distinct problems of its own.

Cream may be the dirtiest part of milk; that is, it may contain many more bacteria than the milk from which it is drawn. When cream rises, it carries the bacteria along with it just as a snowstorm washes the air. For example, Anderson has compared the number of bacteria in cream and whole milk. The average number of bacteria in the twenty-six samples of whole milk examined was 14,338,000. The cream obtained by gravity from this milk contained

68,690,000, while the cream obtained by centrifugation (separator cream) contained 96,860,000. Further experiments have shown that tubercle bacilli and other pathogenic micro-organisms are carried up by the fat droplets into the cream layer. The fact that top milk or cream contains proportionately many more bacteria than the whole milk from which it is obtained has an important practical bearing upon infant feeding. It is customary to make milk formulas with top milk, but we now see that this may be the most dangerous part of the substance. Anderson has shown that top milk, such as is advised for use in infant feeding, contains from ten to five hundred times as many bacteria per cubic centimetre as the mixed milk.

Cream is responsible not only for conveying the tubercle bacilli, but has also been proven guilty in transmitting typhoid, scarlet fever, diphtheria and other infections. The small amount used in coffee or upon cereals is often sufficient to induce disease. Ordinarily coffee is not hot enough to destroy these infections if they are in the cream.

Cream, being a more concentrated food, keeps better than milk. Separator cream can be made much richer than gravity cream and for this reason is preferred for whipping. Further, it keeps longer, for it can be taken from perfectly fresh milk, whereas gravity cream is usually twelve to twenty-four hours old when skimmed. Cream gradually becomes thicker the longer it is kept, and it is often held for this purpose. Sometimes it is one or two weeks old when used. Very little of the cream upon the market is in as fresh a condition as the milk. Freight rates are proportionately less, and it therefore comes from much greater distances. Much of the cream used by a large city may come from entirely different farming sections from its milk supply. The sanitarian must therefore often make a separate study of the cream, especially in relation to epidemiological studies.

At prevailing prices cream is a luxury. It is a promising

fact that cream is now sold in the large markets at prices varying with its fat content. Thus we have twenty per cent, thirty per cent, or forty per cent cream. A forty per cent cream is evidently thicker and richer than a thirty or twenty per cent cream, and the householder is satisfied to pay a correspondingly higher price. Cream may be thickened in a number of ways: by partial souring, by the addition of lime or other substances, or by homogenizing it. These processes, when used to deceive, are simply frauds.

When cream is agitated or beaten the fine bubbles formed do not break readily, so that it may be whipped until it is stiff almost like the white of egg. If whipped too long or when warm, butter forms. Just why cream will whip into a froth is not well understood. This property has been studied in the Wisconsin Agricultural Station and found to be favored by the addition of lime solution, and is probably due in the first case to the calcium compounds in the milk.

Ice cream. Ice creams are artificially frozen dishes of comparatively recent origin. The term "ice cream" is used in this country to cover a large variety of products containing either milk or cream with sundry flavoring substances. It is often made from the very poorest quality of cream or milk to be found upon the market. It is crowded with bacteria. Investigations in Washington, Boston, and other cities have shown that the ice cream as it is sold to the consumer often contains millions of bacteria per cubic centimetre. Further, the ice cream is frequently made in cellars or other unsanitary places and is handled and transported with a plentiful lack of cleanliness.

Freezing does not kill the bacteria in milk or cream. Ice cream has been proven to convey infections, such as typhoid fever, and there is good reason to believe that it may also be responsible for scarlet fever and diphtheria at times. If tubercle bacilli are in the ice cream they are prob-

ably quite as active as they were before the freezing process. Ice cream is sometimes kept an unduly long time before it is sold, and sometimes it is re-frozen after it has been handled and exposed. There are many other indictments which the sanitarian could draw up against ice cream, including impure flavoring and coloring matters, and sophistication of various kinds. Wherever the industry has been investigated it has been found full of abuses and faults.

Butter. Butter, like the cream from which it is made, contains bacteria and infection in excessive numbers or concentrated form. It has been shown that typhoid bacilli, tubercle bacilli, diphtheria bacilli, etc., may live for months in butter. Butter is often made from cream that is not commercially valid as such; in other words, it is one of the good uses to which bad cream can be put. It may be made from fresh cream or ripened cream. "Ripening" consists in allowing bacteria to grow in the cream, for the purpose of rendering churning easier and for the purpose of developing flavors. Cultures of certain bacteria added to the cream develop flavors that are highly prized.

Butter usually is salted. The salt helps to preserve it and also disguises beginning rancidity. Sweet, unsalted butter made from perfectly fresh cream is a delicacy in Europe and is gaining ground in this country. It deserves encouragement.

Butter is renovated in a number of different ways. Sometimes it is simply boiled, and the resulting product will keep a long time. This peculiar form of butter, called "ghee," is commonly used in India and Central Asia. Another way of renovating butter that has become rancid is to wash it with fresh skim milk. This takes away the rancid taste. Such butter is sometimes sold as fresh creamery prints.

Butter usually has a pure white color, except in the springtime when the cows feed in the fields. Then it has a golden yellow hue. In this country butter almost always contains

annatto, a vegetable coloring-matter which gives it this golden yellow tint. Annatto appears to be harmless, and the practice is so commonly in vogue in this country that it has been permitted.

Skim milk. There is a prejudice against skim milk. In some cities its sale is actually forbidden, and in almost all cities commerce in skim milk is discouraged. It is usually placed in the category with oleomargarine, glucose, and other substances that are used as substitutes. This attitude is very unfortunate, for skim milk is not a fraud, but is a very cheap and very excellent article of diet. It contains all the nutrient substances in milk excepting the fat: it is by far the cheapest form of protein that can be purchased.

Even after average milk is skimmed it still contains nearly ten per cent of solids or nutrient ingredients, consisting mainly of the fats and carbohydrates. As a matter of fact skim milk contains slightly more protein than the same weight of whole milk but only about one half its fuel value. When the cream is removed by gravity the skim milk contains from a trace to 0.3 or 0.4 per cent of fat. Separator skim milk has usually less fat.

The value of skim milk is not generally appreciated. It is usually regarded as a thin dilute food containing little or no nourishment, whereas two and one half quarts of skim milk will furnish nearly the same amount of protein and have about the same fuel value as a pound of round steak. An oyster stew made of one part oysters and two parts skim milk would owe its nutriment more to the milk than to the oysters. Bread made with skim milk would contain more protein than when made with water. The ways in which a skillful cook can utilize skim milk are almost endless, and the protein thus added to the daily ration is a distinct gain.

Buttermilk. Buttermilk furnishes more nutriment than almost any other beverage except whole milk and skim milk, unless it be cocoa and chocolate. The average com-

position of buttermilk is quite similar to that of skim milk, though it contains slightly less protein and sugar and a very little more fat. An ordinary glass of buttermilk would contain about as much nourishment as half a pint of oysters or two ounces of bread or a good-sized potato.

During the manufacture of butter from cream the fat globules coalesce into masses and lumps, leaving the fluid known as buttermilk. Buttermilk, then, has practically the same composition as skim milk, containing all the essential ingredients of the milk except the butter-fat. As a rule buttermilk is sour, owing to the fact that cream is usually permitted to sour before it is churned.

Beverages similar to buttermilk are now found upon the market made either from milk containing all or some of its fat, or from skim milk. These preparations are known as "fer-mil-lac," "matzoon," "Bulgarian buttermilk," "cultured buttermilk" and other trade names.

Condensed milk. Condensed milk, or evaporated milk, according to the standards of purity for food products issued by the Secretary of Agriculture in pursuance of authority given by Congress in the Food and Drugs Act of June 30, 1906, is milk from which a considerable portion of water has been evaporated and contains not less than twenty-eight per cent of milk solids, of which not less than 27.5 per cent is milk-fat.

Sweetened condensed milk is defined as follows: Sweetened condensed milk is milk from which a considerable portion of water has been evaporated and to which sugar (sucrose) has been added, and contains not less than twenty-eight per cent of milk solids, of which not less than 27.5 per cent is milk-fat.

Milk may be condensed or evaporated by various processes. The milk may simply be concentrated by evaporation in large pans, with the aid of gentle heat and a partial vacuum, until much of the water is abstracted. This leaves a thickened fluid which contains all the nutritive properties

originally found in the milk, but will not keep without some special method of preservation. The method commonly employed is sterilization in steam chambers, just as canned corn or canned peas are sterilized. Such milk is actually free from bacteria and will keep indefinitely, unopened.

Another method of condensing milk is to concentrate it by evaporation as before and then to add a large percentage of cane sugar. The sugar here serves the same purpose that sugar does in jelly. Such sweetened condensed milk will keep without steam sterilization despite the fact that it may contain many bacteria. As a matter of fact, the sweetened forms of condensed milk upon the market may contain as many as a million bacteria per cubic centimetre. In other words, the sugar does not kill the bacteria, although it prevents their growth and activity.

Comparative studies made by Jordan, of Boston, show that condensed milk is a very expensive food when its nutritive value is compared with fresh, raw milk. Jordan and Mott have shown that condensed milk is seldom prepared from milk rich in fat. Analysis of several of the samples indicates that in a majority of brands the original milk used was either of low grade in respect to percentage of fat or that the milk had been skimmed. These authorities point out further that the present extensive employment of condensed milk is mainly due to the fact that the consumers believe this product can be largely diluted with water and yield a mixture which closely approximates the composition of milk. This opinion is fostered by the printed matter which appears upon the labels of some of the different brands. By following the definite and often indefinite directions for diluting the condensed milks found upon the market, mixtures are obtained impoverished in all the principal milk constituents. There are three brands upon the market which, when diluted with an equal bulk of water, give a mixture having the approximate food value of average whole milk.

Condensed milk is expensive food at the prices at which it is ordinarily sold. Thus, if condensed milk is diluted with enough water to make a quart of a Massachusetts standard milk (containing 3.35 per cent of fat), the cost of condensed milk exceeds the price of ordinary milk; in some instances it equals the price of inspected milk, and in others is more than that of some brands of certified milk. It follows that condensed milk cannot be employed economically where whole milk is procurable.

At one time condensed milk was widely advertised and advocated for infant feeding. Directions for dilution for this purpose appear upon the labels of most brands. Mixtures made according to the formulæ suggested would be deficient, in practically every instance, in percentage of milk constituents as compared with human milk. One thing is certain — that the infant morbidity and mortality is the highest in babies fed upon condensed milk or proprietary foods. Condensed milk should never be given to a baby without the advice of a physician, and that will seldom be obtained.

The impression that most condensed milk is free from bacteria is not founded on fact. Dr. Slack, when director of the bacteriological laboratory of the Boston Board of Health, found that few of the brands on the market are really sterile. Slack found as high as 10,000,000 bacteria per cubic centimetre in the condensed milk of a certain brand. Counts as high as a half a million are not uncommon.

Jordan and Mott conclude that there is no justification in the use of misleading statements by the manufacturers of these substances, and that this should be prohibited by law; further, that packages of condensed milk should bear a formula for diluting with water so that the resulting product shall not be below the standard for milk solids and fat of any state in which the original product may be sold. This end will only be obtained by state legislation.

Powdered milk. Milk may also be obtained in powdered

form by drying it rapidly. In this process the milk is sprayed into a warm chamber, where it is subject to a current of dry air. Most of the water is thus abstracted, and the milk falls as a fine powder to the bottom. Dryness is one of the best preservatives known, and milk thoroughly dried will keep well and is an entirely satisfactory food for many purposes. Powdered milk resembles whole milk. The heat required to powder it kills the bacteria, and if made from good milk to begin with, it should prove a satisfactory article for certain limited uses.

The milk bottle

We can all remember when milk was peddled from house to house in a wagon having one or two large pails from which the milk was dipped or drawn from faucets near the bottom of the pails. In those days every corner grocery store had a dip-tank or milk can from which milk was retailed.

It is only within the past twenty-five years that the glass milk bottle came into general use. So accustomed have we become to the present milk package that we are inclined to forget that it is a comparatively recent innovation. When the glass bottle came into general use we thought all our troubles were at an end, for here we had a nice, clean-looking, transparent container that seemed the acme of sanitary excellence. It was soon learned, however, that the glass milk bottle might be a source of real danger as well as a great deal of annoyance, so that now a serious effort is being made to find a single service milk package; one that can be used once and then thrown away.

The most serious indictment against the glass milk bottle is that it is apt to become infected and thus spread disease. Further, the bottles are difficult to clean. They are very fragile, and in addition to the loss from breakage the failure to return many bottles adds considerably to the expense. The collection of the empty bottles is a constant

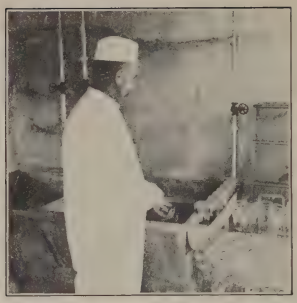
source of irritation and trouble and a considerable item on the wrong column of the ledger.

The liability of the milk bottle to convey infection is its most serious disadvantage. The bottle may become infected in the household in a great variety of ways. To cite instances: A person with diphtheria may drink from the bottle, or it may be taken into a sick-room occupied by a child with scarlet fever, or it may be wiped with cloths that have been infected from a case of typhoid fever, or it may be rinsed with infected water. Milk bottles are sometimes used to hold urine, tuberculous sputum, and other discharges from the body. If such a bottle is again filled with milk without proper disinfection grave consequences may ensue.

The milk bottles are occasionally infected from the hands of the driver, the cook, or other person. A case in point illustrates this danger. A driver of one of the milk wagons in Washington had an open sore on his finger following scarlet fever. We now know that these running sores after scarlet fever frequently contain the germs of that disease. This particular driver left a trail of scarlet fever along his route. The cases stopped abruptly when the fact was discovered and the driver was removed. Milk bottles may also become infected in the dairy if not properly cared for; also during transportation.

The manner in which milk bottles are cleaned at the dairy before they are again filled would not meet with the approval of a careful housewife. In fact, the cleaning of milk bottles is a custom more honored in the breach than in the observance.

In the dairy the bottles are usually cleaned during the daytime and then allowed to stand overnight in order to dry and cool. Not infrequently the bottles are left in an exposed place to collect dust and attract flies and roaches. Flies are the bane of a dairy, and unless the bottles are inverted and carefully protected they are apt to become soiled. During the still hours of the night mice



BOTTLES WASHED BY HAND. SUCH BOTTLES MUST SUBSEQUENTLY BE SCALDED OR STEAMED, FOR THE HANDS CANNOT STAND WATER HOT ENOUGH TO DISINFECT THE BOTTLES

MILK BOTTLES WASHED WITH THE FAMILY LAUNDRY. ONE OF THE WAYS INFECTION GETS INTO MILK. THE MILK INDUSTRY MUST BE KEPT SEPARATE FROM THE HOME INDUSTRY

MILK BOTTLES BEING FILLED AND CAPPED BY MACHINERY. THE ONLY PROPER METHOD

run over the bottles looking for stray drops of food. I have found mouse fæces in a bottle of milk, which doubtless got in while the bottle was empty. Roaches and other insects get into the milk bottles in a similar manner.

The cleaning of the milk bottle is a difficult task. Where large quantities are handled it is a sloppy, noisy, and disagreeable job. One need only visit a large dairy to convince himself that many milk bottles are returned in a deplorable condition. Some of them are encrusted with a film of dried and decomposed milk; some of them give evidence of having held whiskey, gasolene, paint, turpentine, carbolic acid, etc.; some of them are very dirty. Milk bottles may be cleaned by machinery or by hand. In either case each bottle must be carefully inspected to see that no visible dirt has escaped the process.

Hand cleaning is not altogether satisfactory on account of the incompetent labor usually employed for such work, and also for the reason that the hands cannot stand the high temperature of the water necessary to cleanse and disinfect the bottles properly. In small establishments children often are enlisted for this work. This adds the danger of contamination with the infectious diseases of childhood to the irresponsibility and incompetency of the little workers. A large number of bottles are often washed one after another in a tub of warm water, which soon becomes milky and a good culture medium. In any case the water cannot be used hot enough, when hand methods are employed, to kill germs; hence a separate disinfection must be made, which, in my experience, is rarely carried out.

Washing-machines are more or less effective — especially less, owing to faulty designs and improper attention. In almost all washing-machines the bottles are first douched with an alkaline solution to cut the milk curds and grease; they then pass to a weaker alkaline or soapy solution, and finally to several changes of clear water. In many of the bottle-washing machines the final water is steaming hot so

that the bottles are disinfected and dry quickly when removed. If the disinfection of the bottle depends upon hot water in the washing-machine the greatest care must be exercised to see that it is really steaming hot (automatic registering thermometers should be used), and that the exposure is sufficiently long. I have found in several instances, especially in the older types of machine, that the water was not hot enough to destroy infection, and a false sense of security is thus engendered.

Brewers, who have had a long experience in the washing of bottles, have machines for this purpose which, as a rule, are superior to the machines used in dairies. It is not pleasant to visit the bottling- and pasteurizing-plant of a modern brewery after inspecting a dairy. The contrast is painfully in favor of the beer, which is another organic beverage that spoils readily and must be handled with many of the precautions necessary in the case of milk.

No bottle should be filled with milk unless it has first been disinfected. Practically the only efficient and reliable manner to accomplish this is to flood the bottle inside and out with scalding hot water or to subject it to live steam. It only requires a few moments at the boiling temperature for water or steam to kill all the harmful bacteria that concern us in this connection. It may be a surprise to know that many of the milk bottles in current use are filled and again sent into the trade with no pretense of disinfection. This is a real potential danger, and may well be given the serious attention of the health officer. The law should require all milk containers to be disinfected after each use or before they are again filled.

Milk bottles should always be thoroughly cleansed by the householder before they are returned. Boston, New York, Chicago, and other cities have a law requiring this to be done. Milk bottles should not be removed from a house in which there is a communicable disease, such as typhoid fever, scarlet fever, diphtheria, etc. In such cases

the bottles should be permitted to collect until the case is discharged or until the numbers become too great for the householder to accommodate. They should be taken and disinfected by the board of health in a separate place before they are returned to the dairy. One difficulty with the present pattern of glass bottle in common use is the cup above the cardboard seal. This is a receptacle for dirt, melted ice, etc. Many devices have been proposed to obviate this nuisance, such as parchment or foil caps which cover the entire neck of the bottle. Recently the crown cork and seal has been used to close milk bottles. These are the familiar tin caps used to seal beer bottles, ginger ale, and other drinks. The seals, to satisfy the sanitarian, must, in themselves, be clean and must be so arranged as to keep the milk in, but the dirt and bacteria out. Whatever form of stopper is used, it is of some importance that it should be so arranged that if opened and the contents tampered with in any way the seal will tell the tale.

It is not unknown that drivers make pints out of quarts or quarts out of pints, provided they run out of either quarts or pints while delivering milk. This would not be possible if the seals were of such a character that they could not be tampered with without showing evidence that the bottle had been opened. In one of my early morning investigations I once noticed a driver making quarts out of pints. He filled the empty quart bottles which he had collected that morning from two pint bottles and closed the quart bottle with a paper cap which he carried in his vest pocket. Not only was the quart bottle not cleansed or disinfected before it was filled, but the driver conscientiously licked the neck of the bottle "clean" so as not to leave evidence of his act.

The single-service milk package

The disadvantages of the milk bottle have directed attention toward the individual package. Many forms, shapes,

and styles of single-service packages have been brought forward by ingenious inventors, but it appears that none of them entirely comply with the requirements of the case. It is comparatively easy to make a paper bottle which satisfies the requirements of the sanitarian, but it seems that if such bottles are sufficiently strong and made of good stock, with a satisfactory impervious coating and a tight seal that will keep the milk in, and so shaped as to keep the dirt out, the expense becomes prohibitive. Improvements are constantly being made to cheapen the individual paper package, and there is no doubt that it will ultimately replace the glass bottle.

A disadvantage of the paper bottle is that it is not transparent, so that it is not possible to see the cream line or to detect dirt. This is not such a serious objection, for the reason that health officers should guarantee the cleanliness of the milk as well as its butter-fat content. Further, it is not at all impossible that in time a single-service package will be devised which is transparent. The individual milk package is the package of the future. The glass bottle is doomed, just as the common drinking-cups and roller towels are fast becoming relics of the sanitary dark ages.

Milk utensils

Milk pails, milk cans, and other milk utensils should be made of tin. This is the least objectionable metal and the easiest to keep bright and clean. Tin is not acted upon very much by milk and does not furnish poisonous salts, such as may come from copper or other metals. Pails and cans should be free from rust, the surfaces must be kept bright, and they must be so constructed that they may be readily cleaned. The seams especially should be tight and be entirely free from grooves, ridges, or irregular surfaces. Metal sieves are objectionable because they are apt to rust and they are difficult to clean. Good dairy utensils

FIG 1. ATLANTIC PAIL.

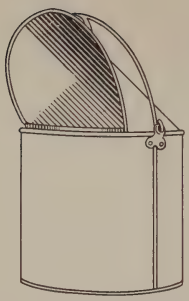


FIG. 2 CHAMPION PAIL.

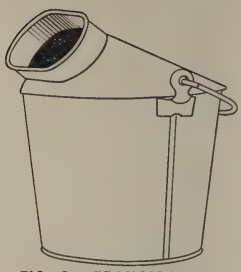


FIG. 3. FRANCISCO PAIL

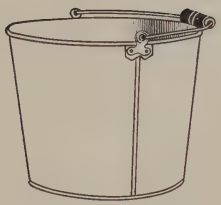


FIG 1 OPEN PAIL.

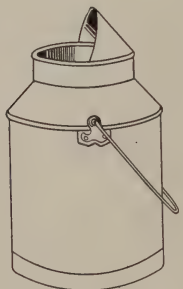


FIG. 2 FREEMAN PAIL
(BETTER FORM)

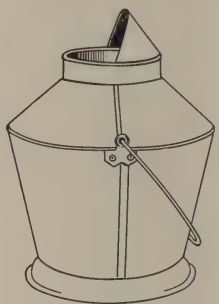


FIG. 3 FREEMAN PAIL
(POORER FORM)

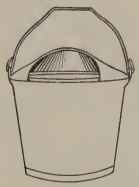


FIG 1 STORRS PAIL

FIG 2 LOY PAIL

FIG 3 MODIFIED LOY PAIL.

FIG. 1 GURLER PAIL.

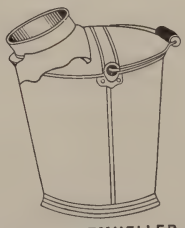


FIG 2 STADTMUELLER PAIL.

FIG. 3. NEWBURGH PAIL.

MODERN MILK PAILS

are more expensive when first cost is considered, but pay in the long run.

The milk pail. The milk pail of two generations ago was commonly of wood, with slightly flaring sides, but this has been gradually supplanted by a metal pail of the same general form. At present these flaring-sided, open-topped pails are in use in practically all of the ordinary dairies, the improved pails having as yet been adopted in only a few of the more progressive ones.

A satisfactory milk pail constructed upon scientific principles will, in itself, exclude one half or more of the germs which fall into an ordinary open pail during the milking process. The pail should not be more than twelve inches high over all. One of the commonest failings of covered pails is their excessive height, which renders the milking of short-legged or heavy-uddered cows awkward and difficult.

Harding points out that an elliptical opening is preferable to a round one covering the same number of square inches, since it is easier to milk into. For ordinary milkers the opening should scarcely be less than 5×7 inches, and with a little practice this has been found practically as convenient as the ordinary open pail.

The cover should be sufficiently convex, so that the entire inside of the pail can be seen and easily reached for cleaning. It should be made flush with the very top of the pail, so as to avoid a groove which will conduct material from the top of the pail around to the opening and into the milk. The various forms of covers and openings are shown in the illustrations, which speak for themselves. Those of the Stadtmüller, Star and Neuberg type, and also those of the Truemann, Storrs, or Loy type, are satisfactory both in the ease of milking and protection afforded to the milk.

A suitable cover soldered to an ordinary milk pail by a local tinsmith will give satisfaction if the work is well done and all the seams are carefully filled with solder. Such a

cover adds about fifty cents to the cost of the original pail.

The milk can. A large amount of thought has been given to the construction, form, and size of the milk can. Milk is usually transported in heavy cans, usually holding twenty, thirty, or forty quarts. The styles in use differ markedly according to locality. The style of milk can used in most parts of the country has a well-designed lid, so constructed as to keep dirt and bacteria out of the can. In New England the small eight-and-a-half-quart milk can is still in common use, for the reason that so many of the dairy farms through this section of the country are the small two- or three-cow farms. These cans have the old wooden stopper, which is objectionable because it does not fit well and is difficult to cleanse, and has no hood to shed the dirt. Milk cans are frequently made with locks, so that they cannot be opened and the contents tampered with before they reach their destination.

The inside of the can must be smooth and so joined that all ridges, grooves, or irregular surfaces are avoided. This not only facilitates cleaning, but prevents the accumulation of old, sour milk which contaminates the fresh milk as soon as it comes in contact with it.

All progressive milk laws require milk cans to be cleansed before they are returned, and prohibit their use for any other purpose. It was formerly the custom of hotel men and others to return swill to the farmer in the milk can for the purpose of feeding the hogs. Such use of the milk can is highly objectionable and is justly prohibited by law.

Milk for large cities and small towns contrasted

It has frequently been suggested that higher standards should obtain for the milk supply of small towns than for large cities. This would be a mistake. The milk standards should be the same the world over, in city, town, or hamlet. Small communities, however, should, under existing condi-

tions, obtain more milk of the higher grades than large cities and no milk of the lower grades. It is evident that the problem of supplying fresh milk to furnish the needs of a small town is comparatively simple, compared to the milk supply of a large city. The small town drains a smaller area, and most of the milk is within wagon haul. Such milk brought into town will be fresh and have comparatively few bacteria. However, this same milk taken several hundred miles to the city would probably be old, bacteria-laden, and unsatisfactory. For although the milk may be fresh and contain comparatively few bacteria, it may, nevertheless, contain infection.

While little attention is paid to small outbreaks of disease, a large epidemic often proves to be a life-saver, for it thoroughly arouses the sanitary conscience, opens up the public purse, and gives the sanitarian authority to accomplish sanitary reforms.

The dip-tank

The day of the dip-tank is doomed. It is unnecessary and a source of infection. There is evidently greater reason for handling milk in safe and clean individual packages than there is for soda crackers or breakfast foods. As a matter of fact, the dip-tank is fast disappearing, but holds tenacious sway in the corner grocery store and a few other places. Dip-tanks are objectionable because they often are in an unsanitary condition and in surroundings that make it difficult to keep them clean. In dipping out the milk, some of it runs back over the hands or pitcher into the tank; in other ways infection and dirt are apt to be introduced. The main advantage of the dip-tank is that it saves money, which is a very great consideration, especially in the poor districts of the city. It is also easier for the dairyman, as it saves the trouble and expense of the bottling nuisance. Good milk of high quality is never purveyed at retail as loose milk. Therefore milk sold from dip-tanks at once

comes under suspicion. As a matter of fact, investigations in many cities have shown that loose milk is usually very poor milk, dirty and full of bacteria. The mothers of the poor often buy such milk for their babies, because it is somewhat cheaper than bottled milk.

In New York the Committee for Reduction of Infant Mortality found that the loose milk declared by the Department of Health to be unfit for babies is used by a large proportion of mothers in the poor districts. The committee investigated 182 shops that sell about 14,000 quarts of loose milk daily and found these stores to be operated under most unsanitary conditions. Many were filthy, foul-smelling, and swarming with flies, and the utmost carelessness manifested in the care and handling of the milk.

The bacteriological examination of the milk in Boston shows that the poorest milk is sold from stores. Boston has a limit of 500,000 bacteria per cubic centimetre. The relative percentages of the samples of milk that exceeded this number according to Board of Health figures were as follows: —

At the place of production	1.5 per cent
Upon cars on arrival at city	12.4
From peddlers' wagons	45.6
Stores	71.5

Similar conditions have been found in Chicago, New York, and other cities where the matter has been investigated. As a rule, these stores are located in those districts of the city which has the highest infant mortality. The prohibition of the dip-tank, therefore, discourages the sale of this low grade of milk.

Tanks with faucets at the bottom and good fitting lids present less objection if well cared for. But even in this case the milk must frequently be stirred before it is drawn, otherwise the first purchaser will receive all skim milk and the last all cream. Most cities now forbid milk to

be sold from dip-tanks, but a regulation recently promulgated by the Boston Board of Health to this effect was declared unconstitutional. A legislative enactment designed to give the Board of Health authority to forbid dip-tanks was vetoed by the Governor. The dip-tank will disappear spontaneously as soon as the people are educated to demand their milk in clean original packages.

The dangers in the association between the milk industry and home life

Most diseases of man are contracted from man. Human contact with milk is therefore one of the main things to be avoided. A few of the harmful bacteria in milk come from the cow, such as the bovine tubercle bacillus and virulent streptococci. Human infections are, all told, most frequent and most serious. They are mainly typhoid fever, scarlet fever, diphtheria, and sore throat. A milk business which is run as a home industry is like living upon a volcano. Sooner or later disease will invade the home, and then there is grave danger that it will be communicated to the milk. The danger is increased if children wash the bottles, milk the cows, or in other ways handle the milk.

A close connection between the home life and the milk industry is often seen in the corner grocery store. I have seen this condition: a small grocery store connected directly with the bedroom in which lay a child sick with typhoid fever. There was no law to compel the child to be sent to a hospital, and there was no law to prevent the sale of milk from that grocery store during the time of danger. The father of the family was a street-car conductor and absent all day. The mother tended the store and cared for her maternal duties as best she could. The same hands that nursed the child and disposed of the infected discharges also purveyed the milk. In this case the milk was not dipped out of the tank, but the bottles were handled by the neck, and in some instances bottles were opened in

order to sell a penny's worth. Flies swarmed in and out between the sick-room and the little store. The rest of the picture may readily be imagined.

Labeling

All milk bottles and all milk cans should be plainly and honestly labeled. This would go a long way to solve some of the knotty points in the milk question. The label should state the grade of milk (that is, whether certified, inspected, pasteurized, skimmed, etc.), and should state the approximate fat content (within 0.2 per cent); if heated, the label should state the temperature, time, and date at which the process was done; it should give the name of the dairy, whether the milk is from tuberculin-tested cows, and other pertinent information.

With honest labeling milk could be bought and sold at prices varying with its sanitary grade and nutritive content. To my thinking, honest labeling is one of the most important foundation stones for the whole pure food structure. In the long run dealers will find it to their advantage to tell the purchaser just what he is buying.

When milk is labeled with the date of bottling or the date of pasteurization, then the simple act of placing it in new bottles or pasteurizing it gives it a new lease of life. The only date of real value to the consumer is the date of production. On account of inherent difficulties only certified milk and inspected milk are ordinarily so dated: for market milk and pasteurized milk we must, for the present, be satisfied with the date of bottling or heating.

The transportation of milk

The fact that milk must be transported is annoying and adds to the difficulties of the situation, for nature never intended milk to see the light of day. Special arrangements for transporting it quickly and with due regard for the sanitary requirements are absolutely essential. If the milk

THE INTERIOR OF A NEW ENGLAND MILK CAR — OLD TYPE.
CANS WITH WOODEN STOPPERS

MILK PLATFORM AT NEW UNION STATION, WASHINGTON.
A MODEL ARRANGEMENT

goes by rail, special refrigerator cars designed to carry milk and nothing else must be provided. In fact, large cities require not only special cars, but special milk trains that are run upon an express schedule. The railroads find it advantageous to employ a milk agent with assistants, just as they employ a general baggage agent with assistants. Further, the railroad should provide special sheds in the country and a milk yard in the city with facilities for rapidly handling the goods. The milk trains usually arrive in the city about midnight and bring milk of the morning and previous evening. It is delivered the following day, and is therefore at least twenty-four to thirty-six hours old when it reaches the consumer. The Lackawanna Railroad runs solid milk trains into New York. These trains run on passenger schedules with cars of standard equipment, ventilated and iced. This system has been a gradual evolution from the time when a few cans of milk were carried in the baggage car. Other progressive railroads have similar equipment and service.

The milk wagon has undergone changes with the evolution of the business. The present milk wagon is well designed to carry the glass bottles and a sufficient quantity of ice to keep the milk cold until delivered. The process is an expensive one. The cost of distribution is more than the price of milk plus the cost of bringing it to the city. The drivers of the milk wagons have much more power than is ordinarily understood by the householder. The common arrangement is to give the driver a percentage share of the business. This makes them keen for trade and has the advantage of improving the service. It has the disadvantage of favoring underhanded methods which drivers occasionally use, and is a constant source of irritation and friction between the different dairymen. Some of the other faults and dangers from drivers in improperly handling milk have already been dwelt upon.

The transportation question is cleverly settled in Italy

and many other countries where goat's milk is used. There the animals are driven to the door, even upstairs to the attic apartment, and the goats milked on the premises. Sometimes the baby is permitted to suckle directly from the goat's teat, thereby insuring at least a fresh supply uncontaminated by commercial conditions.

Certified milk and milk of the highest grade must be bottled at the producing farm and transported in the original package. This is expensive, bulky, the breakage is considerable, and the return freight adds to the cost. However, it is necessary for the safety of a high-grade milk.

Scientific research

The economic engineer may give us greater efficiency and diminish cost, but protection to health depends upon scientific research that has come out of laboratories. The sanitary sciences are, after all, the backbone of this whole question. If it were not for the health side there would be no milk question. We are indebted to the science of bacteriology, chemistry, immunology, and the advances in the sanitary sciences generally, not only for opening up but for solving the milk question. The scientist in the laboratory has pointed out the dangers, has led the way, and has given the power of prevention and cure.

Progressive milkmen recognize the value of sanitary research, even though it is of an abstract nature and apparently has no direct practical bearing upon the problems at hand. Some of the fruits of science which are daily used by dairymen in their practical everyday work have been gained in laboratories only through research which, to the average man, appears to be of an abstruse and impractical nature.

Research workers do not always find what they are looking for. The most valuable discoveries have been made by searchers after pure truth in surprising and unexpected directions. Sometimes a new fact seems to have no practical value at all, but sooner or later fits into the mosaic

which makes up the sum total of wisdom. Isolated facts may, even, in time prove to be the keystone of the arch of knowledge. Thus, who would have supposed that the early entomologists who studied the life history and differences in the mosquitoes were preparing information of enormous value to mankind in the control of yellow fever and malaria? Men have been derided for studying the humble flea, but the facts they discovered are now essential for the prevention and elimination of plague. When Metchnikoff studied the little transparent water-spiders under the microscope, people regarded such an occupation as no occupation at all for a sane man, but out of these observations has arisen our knowledge of phagocytosis and much that we know concerning immunity and the prevention of infections. When Pasteur set himself to study the reason why some wines have a sour taste, the average man could see little practical use in such an inquiry, but Pasteur saw curious germs in the sour wine which he soon showed to be the cause of the abnormal fermentation. It was a bold but logical step to conceive that if these little germs caused disease of wine, similar germs probably caused diseases and fevers in man. The patient and plodding research student who sets before himself the task of discovering the cause or cure for cancer is treading unknown paths and may take a road which will lead to a cure for typhoid fever or tuberculosis. The investigator who sails the uncharted seas is apt to discover new islands and new harbors, although not always the ones his imagination conceives. Columbus set out to find a short route to the Indies, but discovered a continent instead. Workers in laboratories are truly pioneers, and useful knowledge concerning the milk problem has resulted from research work often of an academic nature which had no special reference to milk.

These facts are well recognized by many progressive dairymen who foster scientific research. Thus in Boston a number of milk contractors, producers of certified milk,

and the better class of dairymen, have combined, like the old English guilds, to form a fund to foster scientific research. This work is done in the Department of Preventive Medicine and Hygiene at the Harvard Medical School under the auspices of the Milk and Baby Hygiene Association.

Milk preservatives

Chemical preservatives. Many different preservatives have been advocated and used at different times to prevent milk souring. The commonest among these are: boracic acid and borax, formaldehyde, bicarbonate of soda, salicylic acid, benzoic acid, peroxide of hydrogen, common salt, fluorides, potassium dichromate, and so on through a long list of antiseptic substances. The substances most frequently employed are boracic acid, borax, formaldehyde, and bicarbonate of soda.

Von Behring, a distinguished authority, seriously advocated the addition of formaldehyde to milk in order to preserve it. It requires an exceedingly small quantity of formaldehyde to delay the souring of milk. Thus one part of formaldehyde added to twenty thousand parts of milk preserves the milk for forty-eight hours. Formaldehyde is sold to dairymen under the trade name of "Freezine." At one time many samples of milk were found upon the market which showed the presence of this potent germicide. The practice now, however, has largely been discontinued owing to the pure food laws and the activity of health officers. Those who favor the use of formaldehyde in milk claim that the small quantities necessary to preserve milk for a period of twenty-four hours have no appreciable effect upon the digestibility of the milk and are, in fact, less harmful than "tea, claret, or Worcestershire sauce." Yet no one would willingly give such things to babies. They are not always harmless to adults. Formaldehyde in the proportion of one part to fifty thousand, in which dilution it is

occasionally used, does not appear to have any very serious action upon animal tissues or upon nutrition. As soon as somewhat larger quantities are used, the formaldehyde renders the casein of the milk more or less indigestible, retards the coagulation of milk by rennin, and interferes with gastric digestion. The practice of adding formaldehyde to milk is entirely indefensible and should never be countenanced under any circumstances.

Solutions of boric acid were once sold to the dairymen under the name of "Aseptine," and at one time were commonly used as preservatives for milk. Salicylic acid and benzoic acid are rarely used.

The object of adding bicarbonate of soda is not so much to preserve milk as to neutralize its acidity and thus retard coagulation and disguise the taste of souring milk.

An ingenious method of preserving milk was advocated by Budde, who recommended the use of a three per cent solution of peroxide of hydrogen and an exposure to a temperature of 52° C. Peroxide of hydrogen is an active germicide, and the addition of the heat almost sterilizes the milk so treated. Attempts have also been made to remove the traces of hydrogen peroxide remaining in the milk after such treatment. However, these attempts have not proven practicable, and the milk still contains small amounts of the unchanged hydrogen peroxide. The amounts of this chemical proposed by Budde have little or no practical germicidal action, and if employed in sufficient quantities it imparts a taste to the milk and renders it unfit for human consumption. It is not that hydrogen peroxide in small quantities, and when pure, is particularly harmful, but the addition of any chemical preservative to milk must be combated upon general principles.

A simple test to determine whether an antiseptic or chemical preservative has been added to the milk is known as the "souring test." That is, a portion of the sample is placed in a flask and allowed to stand overnight at room

temperature. If the milk sours in this time and curdles normally, it may be taken as an indication that antiseptics had probably not been added. On the other hand, if it does not curdle in this time under these conditions, it may be regarded as possibly containing preservatives, and a systematic search, to determine which preservative has been added, should then be made by the methods of Leach, Van Slyke, and other well-known authorities on the subject.

Other methods of preserving milk. Various other methods have, from time to time, been suggested for the preservation of milk, such as actinic rays, the electric current, pressure, etc.

The actinic rays comprise the violet and ultra-violet portions of the spectrum. In other words, they are the light rays of shortest wave length. These rays are not ordinarily visible to the eye, but are exceedingly active germicides and have potent power in other directions. They are the rays that burn the skin when exposed to the sun, that hasten the hatching of frogs' eggs, that turn the sunflower to the light, that act upon photographic negatives, etc. In fact, they are rays of great potency. In proper concentration these rays are exceedingly powerful germicides. Water may practically be sterilized by subjecting it to the influence of these rays, and the method is now in actual use. The action of these light rays upon milk is less satisfactory on account of the opacity of the milk.

Milk subjected to electric currents, with the production of electrolytic salts, and milk subjected to great pressure have a certain amount of germicidal action, but the processes are not practical, nor are they satisfactory to the sanitarian.

The proper preservation of milk. The only proper preservatives for milk are cold and cleanliness.

Cold adds nothing to the milk; it takes nothing away. It does not change the composition or quality of the milk;

it delays decomposition, but does not entirely prevent it. Cold is not the most useful preservative we have for fresh organic foodstuffs, but is the least objectionable from a sanitary standpoint. It has the great advantage of being a natural process. Some foods when frozen may be preserved for years without very serious alteration. Thus the flesh of the mammoth imprisoned for centuries in the glacier of Siberia, when uncovered, was still found to be in good enough condition to be eaten by the half-starved natives.

Milk cannot be preserved indefinitely simply by the use of cold. Even at the freezing temperature some of the bacteria continue to grow and multiply, and putrefaction slowly takes place. Milk kept very cold does not sour, but turns putrid because the lactic acid bacteria do not grow at low temperatures, whereas the putrefying bacteria do. Generally, milk should be kept below 50° F., which is sufficient to preserve it for several days. This temperature restrains the growth of most bacteria, and is a deterrent especially to the harmful bacteria. Thus typhoid, diphtheria, and other disease-producing micro-organisms will not develop at this temperature. It would be much better if milk could be kept at 45° F. instead of 50°. This is the temperature requirement for certified milk. While milk should be kept cold, it should not be permitted to freeze, for freezing alters its composition and may render it undesirable, especially for infant feeding.

Freezing does not destroy the pathogenic bacteria. If milk contains the germs of typhoid, diphtheria, scarlet fever, or tuberculosis, the danger is not eliminated even if the milk be frozen. Cold, therefore, while a preservative, is not a germicide. The opposition to keeping milk cold comes mainly from the farmer and the transportation company. The farmer finds ice expensive, and the railroad company complains that it is an additional burden to require it to use refrigerator cars. The opposition, however,

is gradually dying out, for the requirement is a necessary and reasonable one.

Heat, instead of cold, has been proposed to preserve milk. If kept hot enough, milk may be preserved indefinitely. If milk is kept at a temperature above that at which bacteria grow, say about 120° F., it may be preserved even more satisfactorily than by the use of ice. Very few bacteria grow at this temperature and practically none of those ordinarily found in milk. Milk may thus be kept for a long period of time. The plan, however, is not practical; in fact, it is almost impossible to carry out, and is exceedingly hazardous for the reason that if the temperature is not very carefully maintained, the milk will drop to about 100° F., at which temperature bacterial multiplication occurs at its best.

Milk is sometimes heated to the temperature of pasteurization and higher for a short period of time as a preservative. Pasteurization, however, should never be used as a preservative.

Adjusting milk

It is now generally recognized that the mixing of milk from various cows is desirable. Mixed milk furnishes a more uniform product, as it eliminates individual variations in composition and it also has a tendency to dilute infections which may be present. There is no special objection to marketing milk from mixed herds, but there is another form of mixing or adjusting which needs the serious consideration of the health officer. Some dairymen add just enough cream to skim milk to make it comply with the legal percentage, sell this as normal milk, and make money. In fact, to prevent illegal blending or adjusting milk according to scientific manipulations now requires the watchfulness of the law, for such manipulations have to a large extent taken the place of the old-style crude watering or skimming. When milk is diluted with skim milk instead of water, it is rather difficult to detect.

Adjusting consists of separating the cream from the skim milk and reassembling the two so that the resulting product will contain just the legal amount of butter-fat. Morally, there is no difference between the man who takes a ladle and skims off some of the cream and the man who adjusts the milk by the more scientific procedure as above stated.

One form of adulteration consists in the mixing or blending of poor milk with good milk in order to obtain an average quality. This practice can be prevented only by a sharp outlook on the part of the inspectors.

Milk legislation

Milk legislation is primarily a health question and must be considered accordingly. The economic side of the milk question, however, is so important that it must be given due consideration. Unless this is done in drafting milk laws and regulations, they are doomed to failure.

Milk laws should be administered by the health authorities. There is good reason for having lawyers, administrators, producers, and practical dairymen represented upon boards or commissions to frame milk legislation. In all cases, however, such laws should be administered by the health authorities.

In framing milk laws and regulations a verbose style should be avoided. Legal phraseology often puts the sanitarian to rout. A good law, properly worded, is difficult enough in order to provide for all legal possibilities and at the same time be stated in plain language. When such laws are framed by amateurs the result is often a grotesque combination. The following is an example of such an enactment: —

If any person or persons refuse to comply with or willfully connive at or assist on a violation of any of the provisions of this ordinance, or whoever in any manner interferes, hinders, ob-

structs, delays, resists, denies, prevents, or in any way interferes or attempts to interfere with the city chemist, assistant city chemist, or milk inspectors, or police officer, in the performance of any duty herein enjoined, or shall refuse to permit such officials or others to perform their duty, by refusing them or either of them, entrance to any premises where milk or cream is stored or kept, or where cows are stabled or kept, or refuses to permit any animal to be viewed or inspected or any milk or cream to be viewed, inspected, tested or analyzed, or samples to be taken for such purposes, or conceals any milk or cream; or any milk-wagon driver, milk peddler, or milk vendor, who, with his wagon, carriage, or vehicle containing milk or cream, or any person delivering milk or cream by the hand, runs or drives away, or attempts to run or drive away, or conceals or attempts to conceal any milk or cream in his possession, custody, care or control, from any of the officers aforesaid on being approached, or hailed, or addressed, by any such officers in the performance of their duties, shall be deemed guilty of misdemeanor and fined not less than twenty-five dollars nor more than one hundred dollars for each and every offense.

If the milk question had been of importance in the days of the Decalogue, we perhaps should have had an Eleventh Commandment which would have been simply: "Thou shalt not adulterate milk." That covers the whole case.

Mr. Whitaker has called my attention to the North Dakota law, one sentence of which contains three hundred and eighty words and is as follows: -

[From Ordinance No. 314, of Fargo, North Dakota, *Sale of Milk*]

Section 18. *Inspection of premises, etc.* — The milk inspector shall personally visit each dairy and the premises from which any milk or cream is offered for sale or sold in the City of Fargo under this ordinance at irregular intervals, without notice, and at least six times in each year, and thoroughly inspect said premises and the stables and barns in which said cows are kept and milked, and the places where any milk or cream is kept, and the vehicles and receptacles used in transporting such milk or cream, and the vessels and utensils used in connection with the same, and the methods of handling and caring for milk and cream on said prem-

ises and in transportation and delivery of same, and shall also inspect the cows from which such milk is taken, and see that such premises are kept clean and well ventilated, and in good sanitary condition, and that all offal, manure and other refuse is properly removed from said stables, and not allowed to accumulate around or be piled against the same, or in the yards adjacent thereto, where such cows usually congregate, or pass through, and see that such cows are in good health and condition, and that all vehicles, receptacles, vessels and utensils used in connection with said dairy are kept clean and in good sanitary condition, and shall give the licensee such instructions and directions relative to the sanitary condition of such premises and dairy herd, and the condition of the barns and stables thereon, and yards in connection therewith, and the condition of such vehicles, receptacles, vessels and utensils and relative to the handling and caring for such milk and cream, as shall be necessary to secure the provisions of this ordinance, and if such inspector shall suspect the presence of tuberculin or other diseases among such dairy herd, he shall immediately test and tag such suspected animals and if found diseased, such animals shall be separated from the herd, and quarantined or otherwise disposed of as required by the inspector, and such inspector shall at all times have the power to cause any animals, in any dairy herd from which milk is sold or offered for sale, in this city, to be so inspected and tested.

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The solution of the milk problem

To keep milk clean, we need inspection. To render milk safe, we need pasteurization.

Inspection goes to the root of the problem. Through an efficient system of inspection, the milk supply should be cleaner, better, fresher, and safer. Inspection, however, has limitations. These limitations may be guarded against by pasteurization.

A milk supply, therefore, that is both supervised and pasteurized is the only satisfactory solution of the problem.

THE END

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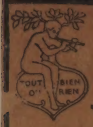

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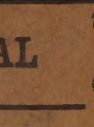

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